COMMITTEE FOR THE REDEVELOPMENT OF MONTSERRAT

DEVELOPMENT OF AN AIRPORT FOR MONTSERRAT

INDEPENDENT ASSESSMENT OF POTENTIAL AIRPORT SITES

PREPARED BY
LEADING EDGE AVIATION PLANNING PROFESSIONALS

APRIL, 2002

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INDEPENDENT ASSESSMENT OF POTENTIAL AIRPORT SITES ON MONTSERRAT

DRAFT STUDY REPORT

EXECUTIVE SUMMARY

E 1.0 STUDY PURPOSE

This study has been commissioned by the Committee for the Redevelopment of Montserrat, with the objective of carrying out a brief, independent, assessment of the potential airport sites on the island of Montserrat. These are sites that have already been identified in earlier studies, and the aim of this study is to determine by evaluation which site, or sites, might be the best candidates to serve long-term air transport requirements of the island. An associated objective was to determine whether, or how, the immediate requirements for fixed wing air access might be accomplished in the context of the most appropriate long-term airport solution.

It is important to note that the terms of reference established by the consultant for this study stress the independent nature of the site assessment. The views expressed in this report are therefore those of the consultant, based on background research and a site visit.

E 2.0 CONCLUSIONS

The study has drawn conclusions from a review of previous studies, discussions with persons having knowledge of the aviation situation and possible airport sites on the island, from analysis of technical materials made available to the consultant, and from a site visit. The following are the primary conclusions of this study:

1. There is a need for the Government of Montserrat to adopt a clear and firm strategy towards airport development, so that the longer-term air transport needs of island residents and visitors can be accommodated. In the five years that have passed since the 1997 volcanic activity, and evacuation of the island, various studies have been carried out and directions identified, with no action taken. At the time of the initial consultant study in 1997, development of an emergency airstrip at Gerald's Bottom was seen as an expedient, and low cost, approach to obtaining emergency air access for the island, until some other solution, including possible re-use of the W.H. Bramble Airport, could be consolidated.

   With the passage of time, the situation has evolved somewhat. Unlike the perceived priority that existed in 1997, there is now a clear need to proceed with development of an airport that can

serve the longer–term interests of the community, since there is no guarantee that volcanic dormancy will be achieved in the near term. However, the present approach being taken is to develop an airstrip with a very short runway at Gerald's Bottom, where expansion is acknowledged to be both impractical and undesirable. This approach is not in the community interest, unless there is a firm commitment to fund the development of a replacement airport, with a longer term capability, within the coming three to five years.

2. The proposal to construct a 500m runway for the Twin Otter may have been appropriate in the emergency situation that existed in 1997, but this can no longer be viewed as satisfactory. Designing an airstrip for this aircraft, when it has been out of production for 14 years, and is likely to be phased out altogether by the airlines over the coming 5 years, is clearly short-sighted. Compounding this, is the fact that the runway proposed is too short for the aircraft types that are already replacing the Twin Otter in airline service in the Caribbean.

3. A more cost-effective approach would be to establish a firm preference for an airport site that can support the longer-term air access needs of the island. Scarce capital funds can then be devoted towards constructing a short runway on this site, as the first stage of an expandable, longer-term, airport. The present approach being adopted will result in an airstrip that cannot feasibly be developed further, cannot support the operational needs of aircraft that will replace the design aircraft, and cannot be used by larger aircraft in the future. Capital funds about to be used for construction of the airstrip at Gerald's Bottom will therefore be poorly invested for no longer-term benefit.

4. For the community, there is a serious risk that once the short runway airstrip is constructed, there will be no further funds available for any replacement future airport. Should this occur, air access to the island will be limited by the size of aircraft that can use the very short runway. Such limitations may not suit the operational needs of the airlines, on which the community will be dependent, and the ability to obtain competitive air service could be jeopardised.

5. The present proposal for a 500m runway at Gerald's Bottom has been planned without consideration or protection for emergency operational situations. For instance, the short runway length cannot enable an aircraft to come to a stop in the event of an emergency, such as an engine failure. Nor can the design aircraft complete a take-off run on this runway with one engine inoperative, unless the payload of passengers and baggage has been restricted in the first place.

6. While the short runway has been planned without any emergency distances being available, the site is such that a deep ravine, some 50-70m in depth exists immediately off the end of the proposed runway strip. Without the facility to

contain a runway overrun, an aircraft that does have an emergency, could run over the edge of the ravine, and with gaining momentum, travel down to the bottom of the ravine. A high probability of suffering structural damage to the hull would exist, and this could possibly result in fire, with injury, or loss of life, to passengers and crew. In view of the presence of the ravines at both ends of the runway strip, and in the absence of any emergency stopping capability, the ravines are a clear hazard to aviation. In a runway overrun situation, the presence of the ravines would be certain to increase the severity of any accident. The present proposal to plan a short runway, without any ability to bring the design aircraft to a safe stop in an emergency situation, along with a hazardous overrun condition, can only be classed as dangerous.

In this circumstance, there would be grounds for parties injured in an accident to seek damages from the owner of the airstrip, from the airline, and possibly from the designers as well.

7. Review of the alternative sites for an airport on Montserrat, has shown a very strong preference for development of the Blake's Estate, as the best site for a long-term airport. This could accommodate a runway long enough for larger aircraft, and may also be able to be designed for both night and instrument operations. A runway constructed at Blake's Estate could be developed in stages. Initial construction could comprise a short runway, fully equipped with the necessary emergency distances, and designed to serve immediate and near-term air access needs. A later extension could be added to the runway to suit market requirements, and the operational needs of the airlines.

   Unfortunately, failure to protect this site, since it was first identified in 1997 as being suitable for this purpose, has already resulted in some encroachment. This takes the form of a football pitch and stadium, and there are understood to be plans for a golf course as well. A conflict of competing land uses would appear to exist. A decision will need to be made whether to opt for this site, and relocate the other uses, or to forego the superior aviation operational benefits offered, and incur a rather greater cost to develop an airport in the northern part of the island. Development of a much longer runway at Gerald's Bottom has been concluded as being very costly due to the major earthworks and filling involved, but more importantly, undesirable due to the serious social disruption such a project would cause.

8. Two sites in the north of the island, at Old Quaw and Thatch Valley, were identified in previous studies as being the only other sites available for consideration, and these have been assessed in this study. Subject to engineering studies relating to the feasibility of site preparation and obstacle removal, both of these sites would appear to have the capability to accommodate longer-term air transport requirements, but not nearly as effectively as the Blake's Estate site. While the ability

to license these two sites has yet to be confirmed, it is clear that both sites would be limited to being available only for visual operations, and night operations would likely be restricted because of the major obstacle formed by Silver Hill. Both sites would also be considerably more costly to develop, due to terrain conditions and consequent earthworks, and both would have a greater susceptibility to either crosswinds, wind turbulence, or both, under strong wind conditions, which appear from local wind data to be infrequent. Of the two, the site at Old Quaw could support a 920m runway, allowing for safety considerations. This would appear to carry a lower development cost than Thatch Valley.

9 In order to proceed with development of an airport for the long-term needs of the community, a series of crucial, and possibly difficult, decisions will have to be taken by the Government of Montserrat.

A possible way forward is outlined in the following section, requiring, firstly, a decision on whether to pursue a long-term airport at this time, or to accept a restricted short runway airstrip at Gerald's Bottom for the foreseeable future. To select the present proposal for Gerald's Bottom, which itself carries a considerable cost, would likely preclude any action to develop an alternative site for many years, and this is not compatible with the aim to develop a long-term airport.

As funds for airport construction are scarce, a decision to develop a new airport, on another site, should also ensure that the approach taken is cost-effective. This means that all energies and investment must be channelled into the new site, and the present proposal to construct an airstrip at Gerald's Bottom abandoned.

Once a commitment is made in this direction, then the objective should be to secure the site at Blake's Estate, as this has the greatest ability to satisfy future needs, and has been consistently ranked superior in evaluations carried out by previous consultants. A strategy towards developing this option is outlined in the next section.

If government decides that the Blake's Estate site is not available, then the only option will be to develop one or other of the two sites identified in the north of the island. Under evaluation, the two sites attracted close scores, with the Old Quaw site having the slight edge, largely due to a probable lower construction cost. However, before a firm decision on these options can be made, further investigation is required, as any site selected for the future airport must be acceptable to the Department of Civil Aviation as a public airport, and issues of compliance with standards and licensing must first be addressed. A strategy towards developing an airport near the north coast of the airport is described in the following section.

E3.0 OPTIONS FOR AIRPORT DEVELOPMENT

There are essentially only three options by which airport development can be approached for Montserrat at the present time.

"No Action Approach" – No Long-Term Airport Development
Gerald's Bottom Option

Under this option, the temporary airstrip at Gerald's Bottom would be developed as planned with a short runway, but based on and restricted to a smaller aircraft, the BN Islander, rather than the Twin Otter, because of the safety implications of the terrain at the ends of the runway. This option would rely on the use of the temporary airstrip for the foreseeable future, pending a suitable period of dormancy of the volcano, which would then permit a return to the Bramble Airport at some time in the future. This option is not a preferred approach, as it would retain a seriously limited airport, and restrict the development of air links for the island.

Long-Term Airport Development Options

If it is accepted that the primary objective should be to commence early development of an airport than can be expended to accommodate longer-term needs, then Blake's Estate is the preferred site. This leads to a crucial decision as to whether, or not, the Blake's Estate can be secured as the site for an airport, or whether the encroaching land uses take precedence.

Blake's Estate Site Option - Site Available
Development of the Site at Blake's Estate

If a decision can be made that Blake's Estate is available for airport development, then it would be recommended that an initial runway be constructed to 700m at least, but preferably 799m, but with the earthworks formation developed on the basis of ICAO Code 2C criteria, so that future extension of the runway can be achieved more easily at a later date. This approach would require relocation and construction of the football pitch and stadium within the cost of the airport project, and these facilities might possibly be relocated to a site at Gerald's Bottom, which is both flat and of sufficient size.

Blake's Estate Site Option - Site Unavailable
Development of a Site in the North of the Island

If a decision is reached that Blake's Estate is not available for airport development, then the two sites in the north of the island would be the next best candidates, and should be re-assessed in terms of their feasibility to accommodate the site preparation needs of a licensable airport. In this, the first priority should be placed on examining the Old Quaw site.

As Old Quaw would take some time to develop, due to the site preparation involved, and there might be a need for a very

temporary grass runway at Gerald's Bottom, to enable use by light twin engine aircraft in the interim.

Provided that the airport development suggested for Old Quaw can meet licensing standards, construction of a runway at this site should initially be for to at least 700m, and preferably 799m, in accordance with ICAO Code 1B criteria. Earthworks should, however, be formed in accordance with criteria applicable to the later extension of the runway to its ultimate limit of 920m under Code 2C criteria. On completion of the initial stage of construction at Old Quaw, the helicopter operation and use of a minimal grass strip at Gerald's Bottom would be terminated, and all aviation activity transferred to the new airport site.

As outlined above, if the "No Action" approach is unacceptable, and this would appear to be the case from information conveyed to this consultant, then a decision must then be made as to whether the Blake's Estate site can be used or not. Depending on this decision, the most appropriate path can then be selected, and funding sought for development of the future airport.

INDEPENDENT ASSESSMENT OF
POTENTIAL AIRPORT SITES ON MONTSERRAT

DRAFT STUDY REPORT

TABLE OF CONTENTS

INDEPENDENT ASSESSMENT OF POTENTIAL AIRPORT SITES ON MONTSERRAT

DRAFT STUDY REPORT

1.0 BACKGROUND

The island of Montserrat has been dependent on subsidised transportation services ever since the W.H. Bramble Airport at Blackburne was closed in June 1997 due to volcanic action. A subsidised ferry service was established in August 1997 to provide the main transportation link between Montserrat and Antigua, and an emergency chartered helicopter service was also established soon after closure of the airport. The helicopter operation currently provides a limited capacity passenger service between Montserrat and Antigua.

It is not known whether the W. H. Bramble Airport can be re-opened in the foreseeable future, and regular commercial air services reinstated. A substantial period of declared dormancy of the Soufrière Hills volcano will have to be fulfilled, before the area of the airport can be declared safe for public access. Given the impossibility of predicting when this might transpire, the Bramble Airport could possibly be closed for decades.

As a result, near-term use of the Bramble Airport cannot realistically be assumed, and the immediate, and possibly long-term, airport needs of the island will have to be satisfied though development of another airport site. This would have to be located outside the volcanic exclusion zone, and limits the choice of an airport site to the northern part of the island.

A number of studies of alternative airport sites, and air transport solutions for Montserrat, have been carried out by consulting firms since the closure of the Bramble Airport in 1997. From these, it has been concluded that there is a need to construct a new airport, with the most expedient solution being to construct a temporary airstrip to serve the island's immediate needs. This could serve until either the Bramble Airport can be re-activated, or until a permanent replacement airport can be constructed, either as an extension of the initial temporary airstrip, or at a new site altogether.

Subsequent to the initial consultant studies of airport options in 1997 and 1998, and a study of the refurbishment of the Bramble Airport in 1999, it appeared that the volcanic activity might be subsiding. However, in late 1999, activity again recommenced, resulting in collapse of a volcanic dome in March 2000 and emission of pyroclastic flows. As a new dome has since been forming within the volcano, resettlement of the southern part of the island, and re-opening of the W.H. Bramble Airport, cannot be considered for the foreseeable future. With the volcanic activity still on-going in 2000, it became clear that the approach to providing an

airport would need to be re-appraised. While a permanent solution to the issue of where, when and how, to create a long-term airport was still a vital concern, the higher priority of Government became the need to construct a temporary airstrip to serve the immediate air transport needs of the island. A decision was therefore reached by the Government of Montserrat to construct a short, temporary, airstrip at Gerald's Bottom, as this was seen to be the least cost approach to satisfying an urgent air transport need. The ultimate intent of the Government of Montserrat is understood to be to construct a new permanent airport at another site. In the meantime, a proposal to construct a 500m paved runway at Gerald's Bottom has been approved, and this airstrip is in process of being designed and constructed, under funding from the UK's Department for International Development (DFID).

There is concern locally that this approach to providing an airport for Montserrat, while appearing to solve the immediate air service needs, might remain as the only airfield on the island for a very long time, if further funding for a permanent solution cannot be obtained. The shortcomings of the Gerald's site as an airport, especially the difficulty of expanding the site for a longer runway, serve to compound the concern of community over selection of this site. If, indeed, the worst fears of the community are realised, then the possibility is raised that Montserrat would be unable to develop its air service links and capacity, beyond those for which the very short runway is capable. This might then inhibit economic development of the island.

A number of differing views have been expressed over the most appropriate future airport site on the island. The proposal to construct a 500m airstrip at Gerald's Bottom has come under criticism for its apparent failure to take a long term view, but at the same time, opinion is not united behind any single alternative approach that might provide the longer–term solution.

This brief study has been commissioned to carry out an overview of the alternative airport sites, and to assess them in the light of their suitability as sites for an airport. The intent is to review all of the background materials and studies, and assess the aeronautical and airport development features of the sites. The objective is to focus the issues and point a way forward, so that the very scarce capital funds available can be employed so that the option to expand any initial development into a long-term airport, can be safeguarded.

The longer-term goal is clear – to develop an airport that can accommodate all of the aircraft types likely to be used in regional inter-island air services in the future, with particular emphasis on accommodating DHC-8 and ATR 42 aircraft as critical design aircraft. However, what is presently lacking is a coordinated approach towards airport development at the local level. So long as there is no single firm approach, it will be difficult for the Montserrat Government to obtain funding, and achieve a long-term solution to the problem of air access.

2.0 STUDY OBJECTIVE

The objective of the project has been to carry out a brief, independent, assessment of the potential airport sites on Montserrat, that have already been identified in earlier studies. By evaluation, the study aims to determine which site, or sites, might be the best candidates to serve the long-term air transport requirements of the island. An associated objective is to determine whether, or how, the immediate requirements for fixed wing air access might be accomplished, in the context of the most appropriate long-term airport solution.

It is important to note that the terms of reference established by the consultant for this study stress the independent nature of the site assessment. The views expressed in this report are therefore those of the consultant, based on this technical study.

3.0 PREVIOUS STUDIES AND AIRPORT ASSESSMENTS

Of the various studies undertaken since the volcanic action in 1997, three are relevant to the issue of establishing an airport for Montserrat. These are:

- Montserrat Replacement Airport Study, Mott Macdonald, August 1997;
- New Airstrip Feasibility Study for Montserrat, Gibb, June 1998;
- Review of Airport Options in Montserrat, Parts 1 and 2, SEA – Aeroporti di Milano, October, 2001.

In addition to these studies, the International Civil Aviation Organisation has conducted its own review of the proposal for a temporary airstrip at Gerald's Bottom, and has assessed the merits of alternative airport sites. A report on this review was presented to the Government of Montserrat in July 2001[1].

[1] " Report on the Visit to Montserrat" , International Civil Aviation Organization, North American, Central American and Caribbean Regional Office, Mexico, July, 2001.

3.1 Montserrat Replacement Airport Study – Mott Macdonald

The UK firm of Mott Macdonald was commissioned by the UK Department for International development (DFID) in early August 1997 to establish the possible locations for airstrips on Montserrat, to advise on their capabilities, and to determine the broad costs of developing the alternative airstrips.

The study reviewed the needs for air services and assessed the possibility of establishing a commercial helicopter service, a seaplane service, and airstrips for land-based fixed wing aircraft. For airstrip development, the consultant defined 4 classes of runway relating to aircraft type and size, as follows:

Level 1 Runway 380m, suitable for aircraft up to 9-passenger Islander (ICAO Code 1A);

Level 2 Runway 600m. suitable for aircraft up to 19-passenger DHC-6 Twin Otter aircraft (ICAO Code 1B);

Level 3 Runway 1100m suitable for 50-passenger turboprop aircraft up to DHC-8-300 (ICAO Code 2C); and

Level 4 Runway 1500m, suitable for 70-passenger regional jet aircraft (ICAO Code 3C).

While the helicopter and seaplane options offered low capital cost solutions to providing air service links for Montserrat, both of these approaches promised high operating costs. The development of an airstrip, with a runway meeting one of the four defined levels (above), was therefore put forward as the lowest on-going cost option, even though higher capital costs would be incurred for initial construction.

A total of five locations for an airstrip were initially considered. These were subsequently short-listed down to only three candidate sites based on their suitability in terms of winds, topography, civil engineering considerations, and micro-climatic effects.

In the final analysis, the three sites selected for further review were Thatch Valley, Blake's Estate, and Gerald's Bottom.

Two options were studied for a site at Thatch Valley, one involving partial reclamation into the sea. Both options considered for Thatch Valley could accommodate the full range of runway lengths required for operations by aircraft, from small BN Islander aircraft to regional jets. The cost of development was estimated at approximately EC$ 320M., of which two-thirds of this cost was estimated as being for earthworks.

A site at Blake's Estate was identified that could accommodate a runway length of up to 600m, which could be extended but possibly not as far as 1100m, and certainly not to 1500m, due to the extensive earthworks involved. The site was deemed to be suitable for development either for small passenger aircraft (6 to 9

passengers), or for aircraft up to 19-passenger DHC-6 types. Extension of a runway to 1100m was not ruled out, but in view of the earthworks involved was noted as possibly being "too difficult". Construction cost for the Blake's Estate option, with a 600m runway, was quoted as EC$ 76M., of which over 80% was calculated as being required for earthworks.

A site at Gerald's Bottom was assessed as being only capable of accommodating a Level 1 runway (380m), at a cost of EC$ 15M, of which only 20% was calculated as earthworks.

The Mott Macdonald study concluded that a very short runway could support the necessary basic air service, and that the site at Gerald's Bottom would be the simplest to develop. However, the study noted that a short runway at Gerald's Bottom could never be lengthened, and its location could conflict with long term development on the island.

The Mott study also concluded that the Blake's Estate site could accommodate a longer runway, but would involve substantial earthworks and be expensive to develop. The other sites at the north end of the island, at Thatch Valley, although unconstrained in terms of their development for an airport, were dismissed as having a much higher cost to construct.

Partly because of the time at which the Mott Macdonald study was done, it did not evaluate the rehabilitation of the W.H. Bramble Airport, and was focussed on the need to create an airstrip for immediate use for the near-term.

3.2 New Airstrip Feasibility Study for Montserrat – Gibb

The study carried out by Gibb in 1998 was a very comprehensive feasibility study for a new airstrip on Montserrat. Besides studying the effect of different air traffic growth scenarios, both with and without continued volcanic activity, the study also assessed the airstrip development options in terms of social and environmental impact, financial and economic feasibility.

Three alternative sites for development of an airstrip were studied in the Gibb study, and in addition rehabilitation of the W. H. Bramble airport was also considered to provide a comparison of costs. The three sites were the same as had been short-listed in the Mott Study in the previous year (i.e. Thatch Valley, Blake's Estate and Gerald's Bottom).

The Thatch Valley site was assessed as being able to provide a 600m runway which could be extended to 1100m. A high initial cost was shown to be likely for the first phase construction. The report concluded that this option could not be brought into compliance with ICAO Standards due to the inability to remove sufficient material from the side of Silver Hill to meet transitional surface safeguarding requirements. In view of this, Silver Hill was cited as forming a major hazard to aircraft under this option. The

cost to develop the Thatch Valley site for a 600m runway airport was estimated at EC$ 380M, with an additional EC$ 13M required to extend this to 1100m, for a total cost of almost EC$ 394M. Earthworks amounted to almost 59% of total costs for this option.

The Blake's Estate site was assessed as being capable of supporting an 1100m runway, with earthworks required to fill the Sweetwater Ghaut and remove some high ground. The sloping site was noted as being unsuitable for any extension of the runway towards the east (i.e. towards the sea). In terms of development cost, Blake's Estate was estimated to require EC$ 80M for a 600m runway, and a further EC$ 26M to extend this to 1100m, for a total cost of EC$ 106M. Earthworks accounted for just over 40% of the total coast of construction for this option.

For the Gerald's Bottom site, the Gibb study found that an airstrip could be constructed at Gerald's Bottom with no difficulty. The site was noted as having good approaches and a good usability from the prevailing easterly winds. A 600m runway was stated as being possible, but that extension of the runway beyond this would involve filling the Quashie Spring ravine, and further east to the next ridge, south of Brimms Ghaut. The study concluded that with this extent of filling, a runway of 1500m could be provided at Gerald's Bottom.

Construction costs for development of an airstrip at Gerald's Bottom were estimated at EC$ 48M for a 600m runway, and an additional EC$ 50M for an extension to 1100m. The total cost was quoted at almost EC$ 98M., of which 39% was calculated to be due to earthworks.

The Gibb study concluded that the lowest cost option was to develop the site at Gerald's Bottom. It noted that the cost to develop Blake's Estate was high in the first phase to create a 600m runway, but less costly to extend to 1100m. The Thatch Valley site was noted as being by far the most costly of all sites to develop in the initial phase (600m runway), but would require a fairly low cost to extend the runway to 1100m. The study noted also that the Thatch Valley site would allow for future development beyond this runway length, as the major cost was in the initial site preparation and removal of obstacles.

In conclusion, the Gibb study ranked the Gerald's Bottom site as being superior to the other two, because of its more sheltered location with respect to winds. Both of the sites at Thatch Valley and Blake's Estate were noted as having cliff faces near the end of the runway, which would generate turbulence from the easterly winds. Because of the very high cost of construction at Thatch Valley, the Blake's Estate site was ranked as second-most preferred site.

3.3 Review of Airport Options in Montserrat SEA Aeroporti di Milano

With funding from the EU, a study was commissioned by the Government of Montserrat to prepare the "Project Definition and Preliminary Design of Airport Options in Montserrat". This work was awarded to SEA – Aeroporti Di Milano in March 2001. Part 1 of the project was directed towards the preliminary design of a temporary airstrip with a 500m runway, to be located at Gerald's Bottom, while Part 2 of the study involved a feasibility assessment of a permanent solution at an alternative site.

Part 1 of the study was concluded with a design for a 500m asphalt paved runway, designed for the DHC-6-300 as the critical design aircraft. Airport traffic was estimated to be approximately 60,000 passengers in 2002, increasing to almost 80,000 by 2008. At the low end of the range, this represents approximately 200 two-way passengers per day, or just over 5 arrival and 5 departure flights per day, assuming a 100% load factor on the critical aircraft[2].

The proposed 500m runway was planned by SEA-ADM as an ICAO Code 1B non-instrument runway, oriented east-west into the prevailing easterly winds, and with a total strip length of 560m. Runway usability was quoted as 98.7%, which meets wind coverage requirements.

Information was provided in the study report concerning the runway requirements of other smaller aircraft, as well as other aircraft types of similar size to the design aircraft. Aircraft such as the BN Islander were quoted as being able to operate unrestricted from a 500m runway, while the 19-seat Dornier 228 was noted as requiring a runway longer than 500m for both take-off and landing.

The runway is planned to permit night visual operations, and mention is made in the report of a need for some navigation aids. No details of this recommendation are given, other than a specification for runway end identification lights and runway edge lights.

In Part 2 of the study, the consultant carried out an assessment and evaluation of three alternative locations for a permanent airport for the island. The three sites evaluated in this study were Thatch Valley, Blake's Estate and a site at Old Quaw, which had been suggested by local residents. Also evaluated was the possible extension of the temporary airstrip proposed for Gerald's bottom, and the re-use of the Bramble Airport in the long term.

Based on this, the Thatch Valley site was deemed to have obstacles to aviation that would be problematic, while the very heavy earthworks, and a need to provide a new access road, would

[2] It must be noted that the runway length calculations made in the SEA-ADM study did not account for take-off at maximum payload as international standard atmosphere conditions were assumed, not those relevant to the Gerald's Bottom site.

require a very high investment in this site. The development of Thatch Valley as an airport was noted as having a low sustainability in terms of its ability to support itself financially (due to the high capital investment), while high environmental impact would also occur.

The site at Blake's Estate was noted as having a high development cost, but its main drawback was stated as being the conflict between a proposed airport on this site, and other social amenities that are already under development. This referred to a football stadium being constructed adjacent to, and possibly encroaching on, lands required for an airport. Generally, SEA-ADM noted that the Blake's Estate site offered a safer aviation operating environment.

In the evaluation by SEA-ADM, a site at Old Quaw was found to have similar problems to the Thatch Valley site, in terms of obstacles. In addition, any runway on this site would also have to be constructed with a sub-optimal orientation out of the prevailing wind direction. Environmental impact was also highlighted in connection with this site.

Further development and extension of the temporary runway at Gerald's Bottom was assessed as a long-term solution. However, a conclusion was reached that this should not be considered due to the very high social impact of development, and the limited operational capability of the site.

Rehabilitation of the Bramble Airport was evaluated as a possible solution to the long-term airport needs of the island. However, this idea was deemed to be too closely related to whether or not the volcano would become dormant in the foreseeable future. As a result, this option was not considered further, as it could not be evaluated with any certainty.

Evaluation of the long-term sites indicated that the Blake's Estate site scored highest, but equal to the option to rehabilitate the Bramble Airport. The option to retain the short runway at Gerald's as the long-term airport was ranked second. Ranking below these, were the options to develop an airport at either Old Quaw or Thatch Valley.

If rehabilitation of the Bramble Airport can be excluded as an option, due to the uncertainty of the volcanic situation, then the Blake's Estate site was found to come out on top in the evaluation, and well ahead of the remaining "green field" site options (Old Quaw and Thatch Valley).

3.4 Summary of Findings of Previous Consultant Studies

As the various studies carried out in the past were done at different times, and for different reasons, their results are to some degree coloured by their terms of reference, and feelings about the volcanic situation at the time.

The first study, by Mott Macdonald, was essentially aimed at identifying an immediate solution to the need to develop an airstrip as an emergency facility. The conclusion that the most expedient option would be to develop a short runway at Gerald's Bottom, is consistent with that approach. Nevertheless, in carrying out its review, Mott Macdonald did consider alternative sites that would have a greater operational capability, but would have higher cost implications, and a longer lead time to develop. In this context, Mott Macdonald suggested that a more operationally-suitable runway could be developed at Blake's Estate, but would involve extensive earthworks and be expensive to construct.

Sites in the north of the island (essentially at, and in the vicinity of, Thatch Valley) were acknowledged to be unconstrained, but considerably more expensive to develop. One option in the north of the island that Mott Macdonald did explore was a site to the northwest of Thatch Valley, which could be developed through partial reclamation into shallow water. This idea was not picked up in any subsequent study for Montserrat, although the very same solution was, in fact, provided for the island of Bequia in St Vincent & the Grenadines, where similar difficult terrain exists.

The Gibb study evaluated the same three basic sites as had been identified by Motts, but the reclamation option near Thatch Valley was excluded. As a result, the actual option evaluated for this area scored poorly in terms of obstacles, even though the Motts' reclamation option would have eliminated that issue.

Ultimately, the Gibb study expressed a preference for development of an airstrip at Gerald's Bottom, as this was stated as being the lowest cost option, when compared to the second-ranked option, Blake's Estate. The Gibb study claimed that while a 600m runway could be constructed at Gerald's Bottom, this could be extended to 1500m, by filling across to the next ridge and beyond. The long-term capability of the Gerald's site was therefore seen as being able to meet all future runway needs, at a price. It has not been possible to verify the claim that a runway at Gerald's could actually be extended to 1500m, and since previous, and subsequent, consultants appear to have considered the Gerald's Bottom site to be incapable of any feasible extension, the prospect of extending a runway to 1500m must be questioned.

However, in the Gibb study, the preference for the site at Gerald's Bottom was, to a degree, influenced by the fact that this was seen as the lowest cost site to develop. This conclusion did not present a balanced comparison, as it is only essentially true when the initial 600m runway costs are compared at the two sites. Gerald's Bottom clearly offers the lowest cost for an initial 600m runway, but any

extension beyond that renders the option very expensive. In fact, based on the costing done by Gibb, the cost to develop Blake's Estate for an 1100m runway is very similar to that for an 1100m runway at Gerald's Bottom (EC$ 106M as against EC$ 98M, or a difference of only 8%). By stressing the low cost of Gerald's Bottom, on the basis of only an initial short runway designed for immediate use, the resulting conclusion was clearly misleading, and may have later influenced a decision in favour of this site.

The studies by SEA-ADM were focussed on moving forward the construction of a temporary airstrip at Gerald's Bottom, while at the same time assessing, and evaluating, the options for a long-term solution to the airport needs of the island. In the evaluation, the prospect of a return to the Bramble Airport was discounted as being impossible to evaluate, given the uncertainty over future volcanic action. Significantly, SEA-ADM also discounted the long-term development of Gerald's Bottom as an airport site, which is a conclusion consistent with that reached by Motts, but in direct conflict with the conclusion advanced by Gibb.

As far as the long-term airport site was concerned, SEA-ADM concluded that the Blake's Estate site was preferred, followed in rank order by the sites at Old Quaw and Thatch Valley.

4.0 CURRENT ISSUES FOR AIRPORT DEVELOPMENT

The main issues affecting the development of an airport on Montserrat are described briefly in the following paragraphs:

1. Air Transport

A reliable air transport link is required between Montserrat and Antigua in the first instance, and ultimately between Montserrat and other islands of the Caribbean, or the ability to connect to such services.

Prior to the volcanic eruption, air passenger traffic was reported to be fairly light, with Montserrat contributing only low load factors on the commercial aircraft serving the island. For the future, the ability to attract an air carrier to serve the island will depend on the airline being able to sustain economic load factors for the type of aircraft they have available, and for which the runway is suitable. The fact that the island will be accessible by air will not, of itself, guarantee a continuity of air service. An airline considering adding Montserrat to its route network will need to be satisfied that economic loads are available, but despite this may need to operate into the island as part of a multi-stop service. This could affect the type of aircraft that they would wish to operate, and whether they might require instrument accessibility to ensure an acceptable reliability of service. The requirements for an airport for Montserrat may therefore be influenced by the requirements of the airlines to provide air services, rather than by selection of a design aircraft with no airline-related basis.

2. Aircraft Types for Airport Development

In the past, the island was served by DHC-6 Twin Otter, DHC-8-100 in regular commercial air service, along with smaller aircraft, such as BN Islander types on a charter basis. Both the Twin Otter and Islander aircraft are no longer in production, and indeed the Twin Otter is no longer operated by some of the airlines of the Caribbean. The youngest of the Twin Otters in service is already 14 years old, and the type cannot therefore be expected to remain in airline service for longer than a further 5 to 8 years. Reliance on 9-passenger Islander aircraft is uncertain, but is also undesirable due to their reciprocating engines and a higher level of unreliability with age.

Replacement types for the Twin Otter are few, the closest reasonable alternative being the Dornier 228, which is also a 19-seat aircraft. While the future of the Dornier company is itself presently uncertain, this model of aircraft will be in service for some time to come[3]. It does, however, have greater demands on runway length than the Twin Otter.

This means that the Twin Otter can only be considered as the critical aircraft for airport design for a fairly short period of time. Planning for this aircraft for short-term use, probably no more than 5 years, is acceptable, so long as the capability exists to accommodate its replacement types, even if that means a longer runway will be required in the near term.

Choice of a critical aircraft for an airport cannot be made in a vacuum. The intentions of the airlines, and their own future fleet acquisitions and disposals must be considered when airport planning is undertaken. Within the Caribbean, the trend in acquisition of aircraft types by the airlines is towards higher performance aircraft, with a higher level of passenger comfort, than has been offered in the past with Islander and Twin Otter types. In the future, therefore, Regional Jet aircraft, DHC-8 models in the 30 to 50 passenger range, ATR-42 and 72 models, and high performance smaller 19-seat aircraft, such as the Embraer 110 Bandirante, will be the types in regular service. Future planning for an airport at Montserrat must therefore consider these developments, even where the need is possibly seen to be rather distant. Early decisions must not, therefore, preclude a natural evolution towards accommodating newer, and possibly larger, aircraft types.

Where an air service market at an airport is small, or marginally economic, it will be necessary to ensure that the aircraft type requirements of the airlines are accommodated in future airport development. For Montserrat, this means that, at the very least, airport development must be capable of

[3] While the Dornier 228 aircraft is no longer in production in Germany, it is still being produced under licence in India.

accommodating DHC-8-300 aircraft at a full passenger load, as these may be used on a multi-stop service, where the island cannot, on its own, support an economic point-to-point operation. The ability to provide a runway length of 1100-1199m would therefore be necessary to safeguard the provision of air service in the longer-term.

3. Aeronautical Issues

Runway Length

The terrain of the island clearly limits the ability to plan and develop a runway that can be extended to accommodate long-term aircraft needs. Unless an airport is constructed by reclamation, such as at the north end of the island, it is certain that the maximum runway length that can be constructed at any (accessible) site on the island will be limited to between about 1000 to 1300m. This would accommodate up to 30-50 passenger turboprop aircraft, which would be consistent with current foreseen long-term needs. However, to preserve the ability to accommodate such aircraft in the future, it is particularly important that any compromise on runway length be very carefully considered, especially if there are no guarantees for any further airport development funding for the future.

Runway Over Run Protection

Small aircraft, such as those in Performance Group C, which includes twin-engine aircraft up to the size of the Twin Otter, are often characterised by requiring a longer distance for landing than for take-off. This means that in performance calculations leading to a runway length requirement, the longer of the landing or take-off distance must be applied, and factored in accordance with the requirements of the Air Navigation Order. However, some aircraft, including the Twin Otter, require a longer distance than either the landing or take-off distance to achieve an emergency stop following an engine failure, or other situation under which a take-off must be aborted. Where such aircraft are to be used, the critical emergency distance must also be available, either as runway, or as a combination of runway with a suitable length of stopway beyond the end of the runway. Where this distance cannot be provided, then the take-off weight of the aircraft must be restricted to that for which, in an emergency, an aircraft can be brought to a stop safely in the emergency distance available.

There are situations where a commitment to take-off is required even in the event of an engine failure, however this is an extreme situation, and not one to be recommended as routine for a commercial passenger airline service.

The requirement to protect for a landing overrun, or an overrun following an aborted take-off, becomes especially important at Montserrat, where there is limited flat land, and the terrain beyond the runway ends at some of the possible airport sites is hazardous. Runway planning will therefore have to be carefully considered, because it is not acceptable to plan, or construct, any runway to the limit of the available flat terrain, where in the event of a runway overrun, an aircraft would sustain serious damage, due to terrain conditions beyond the runway end.

A suggestion has been made that an arresting system comprised of engineered materials might be used in the 30m runway strip beyond the runway end. The purpose of this would be to retard an aircraft that overruns the runway, and therefore reduce the severity of the overrun accident. A system developed by the US Federal Aviation Administration, and known as EMAS (Engineered Materials Arresting System)[4] uses a cellular cement bed for this purpose. The system is designed to withstand the weight of airport vehicles travelling over the bed, but collapse under an aircraft load (so long as the aircraft is heavy enough). The length of the bed has to be constructed to be long enough to retard the critical aircraft at a typical runway exit speed, and assumes that full braking is applied, along with reverse thrust.

A few airports in the U.K. have arresting beds in the overrun areas that are comprised of loose aggregate. These are in place at London City Airport, Southampton and a few other airports. These facilities are also helpful in decelerating an aircraft following in an overrun, and are provided as added safety features.

Such runway overrun treatment should be considered for those airport sites where, in the event of an overrun, an aircraft would be substantially damaged, or destroyed. However, to achieve this, a sufficient distance must still be available beyond the runway end. For the arresting systems mentioned above, neither the US FAA, nor the UK CAA, will give any credit for their use in reducing the emergency stopping requirement for the critical aircraft. Such treatment is therefore an added safety feature, and in all situations the full emergency distances still have to be provided for the critical aircraft.

Obstacles

The nature of the terrain of Montserrat means that, for most of the airport sites considered for the island, the substantial hills on the island will constrain airport development, and may constitute obstacles to aviation. A difficulty in meeting ICAO

[4] "Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns", US Department of Transportation, Federal Aviation Administration, AC No. 150/5220-22, August 1998, as amended October, 2000.

safeguarding requirements has been noted in the earlier consultants' studies at some sites, and this has meant the adoption of minimum standards in the options considered, as exemplified by proposals to design for non-instrument operations.

Before decisions are taken to opt for an airport design that is either in violation of ICAO safeguarding standards in any way, or commits the long-term use of the airport to non-instrument operations, the implications of such decisions will need to be assessed through an aeronautical study. Inevitably, though, any airport developed on Montserrat will require to be certificated by the local regulator for civil aviation[5]. Plans for any airport site development should therefore be discussed with the Department of Civil Aviation (OECS), and concurrence obtained prior to a financial commitment being made at any site.

However, the primary objective in terms of obstacle safeguarding would be to plan for instrument non-precision operations, and provide obstacle safeguarding in accordance with ICAO Annex 14 on this basis. As a first approach to planning any airport on Montserrat, this principle should be applied.

Wind Coverage

The island of Montserrat is subjected to prevailing easterly winds, which blow across the island generally from the east, but also from the southeast at times. To obtain adequate coverage for the prevailing winds, runways must therefore be constructed on an east-west alignment, or close to that alignment, to optimise wind coverage. With such limited flat land, the options for runway orientation are also very limited. Generally, potential airport sites on the eastern side of the island can only offer runway orientations of NNW–SSE through to WNW-ESE, and consequently, wind coverage may be reduced at sites where the runway orientation would be away from the prevailing easterly wind. This includes the original Bramble Airport, which has a runway orientation of NW-SE, as well as the potential site identified at Old Quaw.

In planning for a future airport, the principle should be adopted that wind coverage be optimised, but should not be below 95% at the limiting crosswind for the critical aircraft, which is the recommended limit established by ICAO. Lesser wind coverage can be applied where circumstances dictate, but there is a risk that operations might be limited by crosswind effects where a compromise is accepted.

[5] The Department of Civil Aviation for the Organisation of Eastern Caribbean States, based in Antigua, and acting on behalf of the UK CAA as the ultimate regulator of civil aviation for all of the UK Overseas Dependent Territories.

Wind Turbulence

Wind turbulence, and its effect on flight operations, has been raised as an issue by local residents and pilots. Because of the terrain on the island, the prevailing easterly winds would become turbulent when deflected by cliffs on the eastern side of the island, and by ridges, ravines and hills through the central part of the island. The extent of turbulence will depend on the speed and gusting effect of the wind, and the manner in which it is deflected by the natural terrain. Normally surface winds follow the natural terrain, becoming turbulent when the natural flow is disturbed, and forced to change direction sharply.

Under strong winds, however, all potential airport sites on the island would be susceptible to turbulence, but in different ways. Sites inland, such as Blake's Estate and Gerald's Bottom would be affected by winds that become turbulent as a result of deflection by the ravines and ridges over which wind flows. Sites on the coast, such as Old Quaw and Thatch Valley would be influenced by turbulent winds either rising by deflection at a cliff face, and therefore affect aircraft briefly in the take-off flight path (depending on altitude), or by being channelled around and up the slope of an adjacent hillside. The extent to which this might affect aircraft flight operations will vary, being manageable when the turbulent conditions are experienced as updrafts of short duration on take-off, but being of greater significance when encountered on approach, and especially as downdrafts.

Wind turbulence on the island must, however, be considered in context, as it is only under fairly strong winds, above 15 knots, that turbulent effects would become noticeable. Wind data for the island, from the wind rose for the former Bramble Airport as used by Gibb and other consultants, suggests that winds are calm (below 5kts) for over 20% of the time, and only above 15 knots for 3.6% of the time. Based on this information, susceptibility to wind turbulence would therefore be limited to only a relatively small proportion of the time.

Examination of actual hourly wind data recorded at Gerald's Bottom during daylight hours, shows that winds above 15kts, gusting to up to 30kts are recorded at times, However, these are always associated with, and are the result of, other weather patterns, including the passage of hurricanes through the Caribbean. In particular, there is a close correlation apparent in the wind data between high winds above 15kts, and the presence of thunderstorms and low ceilings. In these conditions, aircraft would not be flying, especially at a visual airport. The wind data also show that, following the passage of a thunderstorm, wind velocities fall sharply to below 15kts.

Wind turbulence generated by high winds is clearly a phenomenon that from the recordings made can be related to a weather condition in which aircraft operations would likely not

be occurring. That is not to say that turbulence would not exist at times that weather minima are above visual limits, but that such occurrences would not be frequent, or prolonged.

Wind turbulence studies have been specified for the planning of the Gerald's Bottom site, and suggested as a means of determining the magnitude of turbulence at other candidate airport sites on the island. It is understood that wind turbulence testing has been carried out for the Gerald's Bottom site, but it is not known how data from this test programme has been related to aircraft flight performance, in order to correlate turbulence against wind speed, presence of nearby weather systems, or indeed against an unintentional upset of an aircraft's flight control surfaces.

Operational Requirements

An issue of operational reliability will arise for the longer-term operation of commercial flights to and from Montserrat, if an airport on the island is developed for visual operations only. While visual operations would, in all likelihood, permit a high degree of accessibility, there is a need to enable commercial air traffic to operate on flight plans under instrument flight rules. Even if an airport has to be developed on the basis of compliance only with visual standards, an instrument aid will be necessary. This is to enable air carriers to file IFR flight plans to the island, and to enable cloud-breaking descent procedures to be available, and so allow descent below any cloud base, down to visual minima.

Any planning for an airport on the island will need to be undertaken with the issue of instrument operations in mind.

4. Implications of Topography

A major issue for development of an airport in the northern part of the island is that, with the exception of the area of flat land at Gerald's Bottom, all of the possible airport sites that might be considered for long-term use will involve heavy earthworks. The quantity of earthworks varies from site to site, but in all cases is considerable, and results from a need to fill ravines, remove high ground and eliminate obstacles. The implication of the issue of earthworks is that the cost of construction is high, especially where heavy earthworks will also involve excavation and removal of rock. Evaluation of alternative airport sites necessarily involves consideration of the likely earthworks quantities, and the cost of shaping a platform on which to construct a runway and associated airport facilities. Some of the cost estimates calculated by Gibb in the 1998 study show a high proportion of the cost being for earthworks (40% of total cost for Blake's Estate, almost 40% for a similar development at Gerald's Bottom, and 60% at Thatch Valley).

5. Cost-Effectiveness of Airport Development Staging

An issue of some importance for airport development on Montserrat is that the Government of Montserrat appears to have no clear strategy towards developing a long-term solution to the need for an airport for the island. The opportunity to adopt a single direction was available at an early stage, when the original Mott Macdonald study pointed a way forward for the long term. Unfortunately, this was not adopted as a policy and the current situation is the result, whereby a temporary airstrip with no realistic long-term potential is being proposed as a matter of urgency. At the same time, incompatible development has encroached on a nearby site that had been rated as suitable in the original consultant study 5 years ago.

The present issue facing the Government of Montserrat with respect to airport development is, therefore, to determine a preference for a long-term airport site, and to direct all energies towards achieving its development. Fundamental to a strategy is the need to ensure a cost-effective approach, and to channel the very scare initial funding into a staged development of a long-term solution. For expediency, this may mean constructing a very temporary "minimum scope" initial airstrip as an emergency facility, but for reasons of cost-effectiveness, this approach can be limited to a lower standard of construction than is presently proposed, and therefore at a lower cost as well.

5.0 REVIEW OF THE PROPOSAL TO DEVELOP AN AIRSTRIP AT GERALD'S BOTTOM

The proposal to construct a temporary airstrip at Gerald's Bottom has been assessed on the basis of available information. This has been principally the study prepared by SEA-ADM, but with the benefit of a site visit as well. Only certain features of the proposal relating to airfield development, aviation safety and airport development strategy have been reviewed at this stage, and repetition of discussion already covered in earlier consultants' reports has been avoided.

5.1 Runway Length

Although earlier consultants' studies had proposed a 600m runway at Gerald's Bottom as a temporary runway, the SEA-ADM study was firmly focussed on a 500m runway, although it is not clear how this runway length was finally determined.

Review of the SEA-ADM reports shows that the consultant quoted runway take-off and landing distances based on the international standard atmosphere (ISA), which reflects aircraft performance at sea level and at 15° C, rather than the conditions applicable to Gerald's Bottom (550ft ASL and 32° C reference temperature).

Consequently, the runway length calculations made by SEA-ADM show shorter lengths than would actually be the case under the correct atmospheric conditions. SEA-ADM also assumed that winds would reduce both take-off and landing distances, which is true, but this is never used as the basis for runway planning, as wind strength at any time cannot be predicted, and must not be assumed.

Runway take-off and landing distances for the Twin Otter at 550ft ASL, and at the reference temperature of 32° C, have been re-calculated using De Havilland Canada technical data for the DHC-6-300 aircraft. This calculation, which is based on there being no obstacles in the take-off flight path, resulted in the following required distances for operation at maximum gross weight for take-off, and maximum landing weight for landing. Accelerate-stop distance (emergency distance) has also been calculated for the same conditions.

The re-calculated operational distances are provided in the following table.

Operational Distances for Gerald's Bottom Airstrip
DHC-6-300 Aircraft at 550ft ASL / Reference Temperature 32º C

Operational Conditions	Required Distance
Takeoff Distance to 15.2 m (50ft)	540m (1772ft)
Landing Distance from 15.2 m (50 ft)	495m (1607ft)
Accelerate-Stop Distance	700m (2297ft)

Source - De Havilland Canada Document AEROC 6.2. G. 6-2

From the above, it is clear that take-off at maximum gross weight would require a take-off distance of 540m. Similarly the landing distance required is 495m. For take-off with both engines operating, where the runway is only 500m in length will therefore require a clearway of 40m to be declared to enable take-off at maximum gross weight. In the absence of a clearway, where only 500m is available as the take-off distance, a weight restriction penalty of 170kg would be incurred on take-off. This translates into a payload reduction of 2 passengers and bags, or a reduced fuel load, equivalent to a reduction in range of approximately 120 nautical miles.

However, as the above table indicates, the accelerate-stop distance required for the DHC-6-300 is 700m at the altitude and temperature applicable to Gerald's Bottom. As this is greater than either the take-off or landing distance, the accelerate-stop distance is the critical consideration. If a 500m runway is provided, then to comply

with accelerate-stop requirements, a 200m stopway will also be required beyond the end of the runway. To do this will also require that the runway strip be extended to include the necessary stopway distance, and this has earthworks and grading implications.

In the event of engine failure, the DHC-6-300 will normally require a take-off distance of 960m for a single-engine take-off at 550ft ASL and 32° C. Where no stopway is provided to permit an emergency stop, and the crew has to elect to continue take-off on one engine, the take-off weight of the aircraft would have to be restricted to 4700kg, which means that its payload would be restricted to 13 passengers for a 100 nautical mile sector (including reserves). Where stopway is not provided, this condition will then govern the take-off.

Compounding the issue of runway length, and possible restrictions on take-off weight, will be the manner in which the Twin Otter is deployed in the route network of an airline serving Montserrat. As discussed earlier in this report, if passenger loads generated by Montserrat do not justify direct point-to-point service, and the island is served as part of a multi-stop route network, the seat availability out of Montserrat may be limited by the fact that there would be other passengers on board, travelling beyond the stop at Montserrat. While there may be a need to restrict payload out of Montserrat due to operational conditions from a 500m runway, the actual restriction on uplifting passenger loads from the island may be more severe than is apparent, due to the airline's own route network.

It is noted that the runway length provided under the SEA-ADM proposal will accommodate smaller aircraft such as the BN Islander (380m requirement governed by take-off), but this runway length would involve a weight restriction for operations by aircraft such as the Dornier 228-200 which might be considered as the replacement for the Twin Otter. At the elevation and reference temperature at Gerald's Bottom, the Dornier 228 requires a 600m take-off run, 770m take-off distance, and 730m accelerate-stop distance for operations at the same weight as the Twin Otter with 19-passengers. Clearly, if this aircraft becomes the Twin Otter replacement aircraft of choice by the airlines, the runway proposed at Gerald's Bottom would be inadequate.

5.2 Effect on Runway Performance of Aircraft Turnaround

In order for an aircraft to use the runway at Gerald's Bottom, it will have to turn on the runway at either end. For take-off, an aircraft will have to taxi along the runway from the apron, turn through 180° at the runway end, and straighten up prior to initiating a take-off run. To turn the Twin Otter at the end of an 18m wide runway, allowing for ICAO wheel clearances, will mean that the aircraft will have used 26m of the available runway length, in order to make the turn.

The implication of turning on the runway, is that the take-off run available will not, in fact, be the full length of the 500m runway, but

only 474m. By having to start the take-off at this point, if there is no clearway provided at the eastern end, the 474m take-off run available will equate to take-off distance, and result in a payload penalty of 470kg, which is equivalent to a reduction of 5 passengers and bags, or a range reduction of 330 nautical miles. In terms of the engine-out performance, and in the absence of a stopway, a commitment to a single engine take-off from a 474m runway would require a further take-off weight reduction, to 4650kg, implying a passenger load of only 12 passengers and bags for a 100 nautical mile sector (including reserves). This represents a passenger load factor of only 63% for this operation.

5.3 Choice of Critical Aircraft for Design

For the development of the Gerald's Bottom airstrip, the DHC-6-300 Twin Otter aircraft has been proposed as the design aircraft. This is acceptable for the near term, but only if expanded runway facilities will be available before the Twin Otter types are retired. As production of this aircraft ceased in 1988, the youngest of these types is now 14 years old. Gradual retirement of the type from airline passenger service is already occurring among the older production aircraft, and this can be expected to continue over the coming 5 to 8 years. Already LIAT and Air Caraïbes have ceased to operate Twin Otters, the latter following the fatal Twin Otter approach accident in St Bart's last year. An airport runway designed specifically to meet the performance requirements of the Twin Otter would therefore limit Montserrat to service by the few remaining carriers still using this aircraft. Ultimately, this could leave the community at the mercy of a single airline, and in practical terms this may already be the case.

For very short-term use, the Twin Otter can be considered as the critical aircraft, provided that measures are taken to ensure that future replacement types can be accommodated on the island within the near term. Airlines that have phased out the Twin Otter will be operating types that have a more demanding runway requirement. For instance, LIAT is now entirely equipped with DHC-8 aircraft, while Air Caraïbes has a fleet that includes 11 Dornier 228's. Service by these airlines is therefore precluded, so long as the only airport on Montserrat can offer a 500m runway.

5.4 Approach and Departure Areas

No issues have been identified regarding the approach and departure areas, and these are reported to be clear of obstacles. The approach from the west, which would be the normal approach direction due to winds, passes over housing.

Safeguarding for approach and departure surfaces at Gerald's Bottom for a Code 1B non-instrument runway was stated as being possible by SEA-ADM, as the areas are free from obstacles. What is not clear from the SEA-ADM report is whether the single engine

out climb profile was checked for obstacles, at the limiting single engine climb gradient for the critical aircraft.

5.5 Runway Over Run Protection

The proposal by SEA-AML is to construct a 500m Code 1B runway, with a strip of 560m in length, which allows for the mandatory 30m runway end distance at each end of the runway.

The plan developed by SEA-ADM does not include provision for a Runway End Safety Area (RESA) to accommodate runway landing overruns or under shoots. Nor is provision made for a stopway in the event that an aircraft overruns the end of the runway following an aborted take-off. In the case of the RESA, this is not a mandatory requirement for a non-instrument runway under ICAO Annex 14, although a RESA is recommended[6]. However, as the planned runway length does not meet the accelerate-stop distance for the critical aircraft, there is a need to protect for the take-off emergency condition.

The location selected for the airstrip at Gerald's Bottom is such that it is contained on a narrow area between a deep ravine at the eastern end (Pump Ghaut) and falling terrain at the western end that drops down into another ravine (Sweeney's Ghaut). Both ravines are deep and steep-sided, the one crossing the east end of the runway being about 50-70m deep to the spring below, and the ravine falling down into Sweeney's Ghaut being approximately 25 to 30m deep.

From a safety point of view, in the absence of runway end safety areas or provision for emergency stopping distance, both ravines are of concern. On the west end of the proposed runway, an aircraft undershooting the runway, possibly as a result of downdrafts, would impact on the side of the ravine prior to the runway threshold. Protection for the runway undershoot should therefore be provided in this area.

However, it is the deep, steep-sided, ravine on the east end of the runway that is of greatest concern. This is because the direction of operations on the runway will be from west to east, and this ravine would therefore be in the overrun area for both landing overruns, and aborted take-off situations. As the planned runway is to extend its strip to the top of the ravine, without either a RESA or a stopway, any aircraft that overruns beyond the end of runway strip, would travel down the steep slope to the bottom of the ravine. Because of the steep slope, depth of the fall, and speed at which an aircraft might descend the slope, any aircraft that fails to stop at the end of the runway could sustain severe structural damage in the accident,

[6] There is, in fact, no technical reason why a RESA would be required under ICAO Annex 14 for a Code 1 instrument runway, but not required for a non-instrument runway of the same code. For a non-instrument runway, provision of this safety feature is left to the discretion of the airport designer and operator, based on the safety needs of the particular runway environment.

possibly including rupture of fuel tanks and fire, along with consequent loss of life among the passengers and crew.

The present plan to provide a runway that is unprotected for aircraft overrun conditions, when a serious hazard exists at the ends of the runway, can only be considered dangerous. Aircraft overrun accidents do occur, and for the most part these are non-fatal, because the overrun is normally protected through provision of a RESA, prepared stopway, or benign terrain beyond the runway end. However, in the case of the runway planned for Gerald's Bottom, such protection is not being provided, and the severity of an overrun accident would be increased considerably, with the potential for the accident to become fatal.

As the ravines are known hazards for the runway environment at Gerald's Bottom, any accident occurring as a result of failure to protect for the overrun condition in airport planning or design, could result in claims by injured parties, and next-of-kin, against the airline, the Government of Montserrat and the U.K. Government.

The only way that the proposed 500m runway can be considered to meet reasonable safety requirements is for runway end safety areas to be provided at the runway ends, and for the necessary stopway to be provided for the predominant take-off direction to the east. This should accommodate the accelerate-stop distance requirements of the critical aircraft.

5.6 Runway Safety Environment – Runway Drainage

The SEA-ADM study proposes that runway drainage be provided by means of open channels, running longitudinally along the length of the runway, and located at the edge of the runway strip – 30m from runway centreline. According to SEA-ADM, these channels are planned to be 1m in width, and of varying depth.

Drainage channels can be hazardous to aircraft that leave the runway pavement and travel into the channel. Depending on the depth of the channel, an aircraft could drop a wheel into the channel, and sustain structural damage to the gear, or to the hull, or both. Similar accidents have occurred in the past, and at some considerable cost.

Drainage along the sides of a runway should be provided in such a way that any aircraft that travels into the drain is not damaged. To achieve this, drains should be provided as contoured swales, in accordance with the approach recommended by ICAO in Doc 9150-AN/899 (Stolport Manual), and in ICAO Annex 14 Section 3.10.3. If channel drains are required due to volume of water, these should be covered and capable of supporting the weight of the aircraft.

5.7 Wind Turbulence

Like all of the possible airport sites on Montserrat, wind turbulence can be expected to occur at Gerald's Bottom under suitably strong easterly winds. Due to the slightly inland location, winds at Gerald's Bottom would be moderated by ground friction when flowing towards the airstrip, over the natural terrain to the east. Turbulence would be created by the ridges to the east, and by upward deflection of winds from the side of the ravine east of the runway end. This would result in a turbulent condition in the take-off area during periods of strong winds. While this is believed to be a manageable condition, wind effects may also be noticed on the west side of the airport in the runway approach area. This would result from wind flows following the terrain down into the Sweeney's Ghaut, which could generate downdrafts in the final approach area just prior to the landing threshold.

The extent to which this would occur is not known, and would only be identified from specific wind studies. If downdrafts are found to exist however, these may cause pilots to respond by increasing power and airspeed on final approach, possibly resulting in landing long, or in landing at a higher speed. Where landing distance is critical, as it is in the case of the runway planned for Gerald's Bottom, the chances of a runway landing overrun are increased.

The likelihood of turbulence affecting the operation of aircraft at Gerald's Bottom, or at any other location on the island, must be viewed in the context of the incidence of wind conditions that could give rise to turbulence. From wind data provided by Gibb as part of the 1998 study, it is clear that the incidence of high winds that would generate significant turbulence is actually quite low. From the Gibb wind rose, winds above 10kts would occur on average only 11% of the time, and winds above 15kts, being more likely to generate turbulence, occur on average only 3.6% of the time.

REVIEW OF ALTERNATIVE AIRPORT SITES

Aside from the proposed development at Gerald's Bottom, this study has made an assessment of the principal issues affecting three other potential airport sites. These are at Blake's Estate, Old Quaw and Thatch Valley.

6.1 Blake's Estate

Site Conditions

The Blake's Estate site lies at approximately 198m above mean sea level, and is located to the southeast of Gerald's Bottom. A runway aligned roughly WNW-ESE (11/29) could be developed on this site. Two deep ravines, Cat Ghaut and Sweetwater Ghaut, cross a possible runway alignment at right angles, and construction on this site would therefore require filling across these two ravines.

The site otherwise appears to be somewhat domed, with an ultimate slope away to the southeast towards the sea. Cutting to create a level platform for a runway would be necessary across the central part of the site.

Road access to the Blake's Estate site could be achieved with relative ease, and utilities for an airport would be within easy reach as well.

Part of the Blake's Estate site is already under development, and a football pitch and stadium are being constructed in a location that would be adjacent to a runway strip. A golf course is also proposed for this general location. As a result of these developments, there would be a conflict of land use between the airport and these social amenities, which are already committed. Construction of an airport on this site would require relocation of the football pitch and stadium, and the cost of this would therefore need to be included in any development cost for the airport.

Obstacles

A runway aligned in a WNW-ESE orientation at the Blake's Estate site would not be affected by obstacles. There are some houses under, or near, to the north-west approach to a runway at Blake's Estate at Lookout and Old Norwood. However, these are not obstacles to aviation in the approach area, which is presently clear. Similarly, there are no obstacles to the ESE, in the primary take-off direction.

There appears to be no major reason why an airport developed at Blake's Estate might not be designed to meet instrument non-precision safeguarding criteria, and support an instrument approach to the runway. This possibility should be investigated.

Runway Length Capability

The Blake's Estate site can support a runway of 1100m in length, on an orientation of 11/29. While a further 200m runway extension, to 1300m, could be constructed towards the southeast, the land does fall away in this direction, and any such construction would be very costly in terms of earthworks.

Wind Coverage and Turbulence Issues

Wind coverage for a runway aligned on an 11/29 orientation would be 97.26%, based on the Gibb wind rose data. This coverage is within the wind coverage limit recommended by ICAO for a single runway airport.

Under strong winds from the east, a runway at Blake's Estate could experience turbulence from winds flowing up the ravines. However, the site is slightly inland and wind effects could be moderated by the terrain and vegetation. In general, though, the site is not expected to be subjected to any unusual wind turbulence effects.

Construction Issues

Construction of an airport at Blake's Estate would not encounter any difficulties. Most of the earthwork effort and quantities is in the filling of the ravines, and any cutting in the central area of the site is expected to involve only materials that can be ripped easily.

Long-Term Development Potential

The site at Blake's Estate is capable of serving the long-term airport needs of the island, and a runway with a length of at least 1100m. could be constructed. This will serve aircraft up to 50-passenger DHC-8-300. There may also be a possibility that this site could be developed for both night and instrument operations and, if so, would render this site very valuable for a long-term airport. Unfortunately, development of this site will require relocation and replacement of the football facilities presently under construction, and is also in conflict with plans to develop a golf course. These land use development conflicts may ultimately preclude use of this site for an airport.

6.2 Old Quaw

Site Conditions

The site at Old Quaw is located on the northeast coast of the island, immediately east of Silver Hill. The site comprises an area roughly 250m wide along the base of Silver Hill, running approximately parallel to the shoreline in this area. The eastern limit of the site is formed by a cliff top, approximately 100m above the sea, and this runs along the southeast, east and northwest limits of the site. On the site itself, there are two small hills, one in the south, and one in the centre, of a possible runway alignment. A buttress extending east from the side of Silver Hill forms a partial barrier at the north-west end of the site and the side of silver hill itself encroaches along the west side of a potential runway. These small hills, and much of the buttress, would need to be removed, with the material used for fill, in order to construct a level platform for an airport at this site. Most of the earthworks to remove the hills and buttress would involve rippable materials, but it is anticipated that some blasting could be required.

Old Quaw is presently approached by a 4km track which would require widening, improving and possibly re-aligning in parts, along with surfacing. Utilities to serve an airport would be approximately the same distance away, although there are signs that cable-pulling is underway.

The Old Quaw site has been noted as being of environmental value as a possible sanctuary for birds, and could therefore become a tourist attraction. Construction of an airport at Old Quaw would be in direct conflict with any such eco-tourism development.

Obstacles

With removal of the small hills on the runway alignment, and removal of part of the buttress on the side of Silver Hill, there would be no obstacles to aviation in the runway approach and take-off areas. However, it appears that part of the side of Silver Hill could represent an obstacle in the transitional surface, and a detailed check of this would be needed before confirmation can be given regarding its compliance with ICAO Annex 14 safeguarding standards. If removal of parts of the buttress and side of Silver Hill is infeasible, and encroachments into the transitional safeguarding surface on the west side of the site cannot be avoided, development of the site may not be possible, or acceptable to the Department of Civil Aviation for licensing. Where infringement of safeguarding requirements by obstacles is not deemed to be hazardous to aviation, then dispensation will need to be granted by the DCA for licensing purposes. It is likely that an airport could be constructed on the site for non-instrument operations, but this will need to be confirmed through further study, and restrictions might still be applied by the DCA for operations. It is probable that night operations would not be permitted.

Runway Length Capability

In their study SEA-ADM investigated the development of a Code 2 runway of 1100m at the Old Quaw site. This was aligned approximately 14/32 and its strip extended from the top of the cliff in the southeast to the top of the cliff in the northwest. At each end, the runway was proposed in the SEA-ADM plan to extend to within 60m of the top of the cliffs. In this location, the SEA-ADM proposal offered no protection for a runway overrun. Any overrun during landing, or following an aborted take-off, would result in an aircraft travelling over the cliff, and plunging almost vertically to the sea 100m below. Clearly, the SEA-ADM plan for this airport is highly dangerous, and the plan would therefore require modification.

Review of the need to protect for a runway overrun at Old Quaw has shown that the maximum runway length that could be safely accommodated on this site would be 920m. This length of runway could be provided with stopways to accommodate the runway overrun situation, although it would be recommended that these areas be constructed of materials that could retard an aircraft that travels beyond the runway end. In addition, as the runway take-off run of 920m would be shorter than desirable for use by the DHC-8-300, a clearway equivalent to the stopway distance could be declared for take-off towards the southeast.

Wind Coverage and Turbulence Issues

The runway alignment possible at Old Quaw is NNW-SSE (14/32) and therefore wind coverage from the prevailing easterly winds is lower than for other sites. Using the Gibb wind rose data, the wind coverage for the Old Quaw site is calculated to be 91%. This is below the wind coverage of 95% recommended by ICAO as the lower limit for a single runway airport. While this is still a significant

coverage, it could result in some restrictions to aircraft at times when winds are strong, due to cross wind conditions. These may be unusual situations, however, and associated with thunderstorm activity.

Because of its exposed location on the top of a cliff, winds at the Old Quaw site can be expected to be brisk, even when velocity is moderate. This is because low level winds will strike the sheer cliff faces and be deflected up to the top of the cliffs, becoming turbulent in the areas near to the cliff tops, and adding to the effect of winds at the elevation of the airport platform. Some turbulence, and updrafts, can be expected even under moderate wind velocities for take-off towards the SSE. This will occur principally at the point that aircraft would pass over the cliff top, when climbing on the runway heading. Turbulence could briefly affect aircraft in the climb, but the effect would depend to a large degree on the altitude reached by the aircraft, by the time that it flies across the top of the cliff. Under normal conditions, the turbulence effects, although noticeable at the top of the cliffs, may not extend to a sufficient altitude above the cliffs to affect aircraft that have lifted off well before the runway end.

Turbulence would be less likely to be felt on the approach to the runway from the NNW, except perhaps on short final when winds are sufficiently strong to cause turbulence on the windward side of Silver Hill as they meet the cliff faces and the side of the hill, and are deflected upwards.

Construction Issues

Although the Old Quaw site will require some heavy earthworks to achieve a level platform on which to construct an airport, the earthworks are not anticipated to be difficult to achieve, depending on how much earthworks is involved in establishing a transitional surface on the west side of the runway in the vicinity of the buttress extending from the base of Silver Hill at the northern end of the site. Some rippable rock material can be anticipated, and blasting may be required to remove part of the east buttress of Silver Hill that encroaches onto the site at the north-west end. Earthworks quantities have not been calculated at this stage, but would appear from examination of the contours on the site to be rather less than would be encountered at Thatch Valley.

Long-Term Development Potential

Although the maximum runway length that would appear to be possible at Old Quaw is only 920m, it is, nevertheless, capable of use by the DHC-8-100 and -300 series aircraft. At this length of runway, the DHC-8-100 aircraft could operate with no restriction on payload (assuming a stopway and clearway are developed), while the DHC-8-300 aircraft could operate at a payload of over 80% on short inter-island sectors, such as to and from Antigua. This means that, at the very least, the medium-term aviation requirements of Montserrat could be served by a runway at Old Quaw, while the

longer-term needs could be satisfied to the extent that a payload restriction could be accepted on the larger aircraft.

As far as long-term development of the Old Quaw site is concerned, there are no conflicting land uses, or plans for alternative uses, that would prevent the long-term objective from being realised. There is, however, some interest in preserving this area for eco-tourism.

6.3 Thatch Valley

Site Conditions

Thatch Valley is an isolated site on the north coast of Montserrat. To some limited extent, the site overlaps with the northern part of the Old Quaw site. As with Old Quaw, the site available at Thatch Valley follows the coastline, but is closer to the sea, and part of the site is at sea level. The site is generally at an elevation of 76m above mean sea level, and has a considerably greater range in elevations than any other site considered. This has implications for construction in view of the earthworks quantities involved.

There is no road access, and no utilities nearby, and both would have to be provided, adding considerably to the cost of airport construction.

It is understood that the Thatch Valley area, like Old Quaw, is also under consideration for eco-tourism. Development of an airport at this location would be viewed as having a high environmental impact.

Obstacles

The Thatch Valley site is free of obstacles in the approach area to a runway constructed on a WNW-ESE alignment. In the take-off area, the east buttress of Silver Hill would be an obstacle that would require removal. For transitional surface safeguarding, the buttress slopes reaching north from Silver Hill, and the side of Silver Hill itself, appear to form obstacles on the south side of a runway on this site. This situation appears to exist in more than one place along the length of the runway and, as such, could constitute a hazard to flight operations. The feasibility of meeting the required obstacle safeguarding standards will need to be investigated further if this site is to be considered. If removal of parts of the buttress slopes and parts of the side of Silver Hill is infeasible, and encroachments into the transitional safeguarding surface on the west side of the site cannot be avoided, development of the site may not be possible. Where infringement of safeguarding requirements by obstacles is not deemed to be hazardous to aviation, then dispensation will need to be granted by the DCA for licensing purposes. It is likely that an airport could be constructed on the site for non-instrument operations, but this will need to be confirmed through further study, and restrictions might

still be applied by the DCA for operations. For instance, night operations are likely to be restricted.

Runway Length Capability

With construction of a suitable platform, a runway could be developed at Thatch Valley on a WNW-ESE alignment, with an orientation of 11/29. Although limited at its eastern end by the cliffs and the buttresses of Silver Hill, the runway could be constructed to extend for 1100m to the WNW. The location for the runway, as illustrated by SEA-ADM in their report, is not acceptable due to the proximity of the cliff edge at the eastern end of the runway. A westward shift in the location of the runway, by 150m along the runway alignment, would be recommended. This is to provide an adequate level of safety for aircraft overrunning the runway end on landing, or following an aborted take-off. As the cliff at the east end drops some 75m to the sea, the need for an adequate, and safe, overrun area is vital.

Further extension of the runway on this alignment is also possible, to as much as 1300m. As such, the site offers a capability to accommodate the long-term airport needs of the island.

Wind Coverage and Turbulence Issues

As a runway developed on the Thatch Valley site would be oriented WNW-ESE, the wind coverage available for this runway would be 97%. This exceeds the lower limit of wind coverage recommended by ICAO, and the calculated coverage would therefore be acceptable.

Under strong easterly winds, turbulence in the take-off area could be encountered, as a result of winds off the sea being deflected by the cliffs beyond the eastern end of the runway. As with the Old Quaw site, the extent of wind turbulence experienced would be dependent on the altitude that aircraft would reach by the time that the top of the cliff face is crossed. On the approach to the runway, there could be bumpy conditions encountered on short final due to the surface winds being affected by the ridges and ravines below the approach path. These are not foreseen to be of a hazardous nature, as there are no prominent features that would create dramatic changes in wind velocity or direction.

Construction Issues

The terrain conditions at Thatch Valley are such that construction of a level platform, on which to construct a runway and associated airport facilities, would involve very heavy earthworks. Much of the cut areas would contain rippable materials, but rock blasting can also be anticipated in order to remove buttresses and part of the side slope of Silver Hill. Fill would also be extensive, as the site has a considerable variation in elevations.

Construction of an airport at Thatch Valley would incur very large volumes of earthworks, both cut and fill, and this would result in the cost to construct an airport on this site being very high indeed.

Long-Term Development Potential

The Thatch Valley site does offer a number of benefits, these being a good orientation with respect to wind, and the ability to accommodate a runway of 1100m, with the possibility of extending this further if necessary. The site can therefore accommodate the long-term aviation needs of the island.

There are no conflicts of land use at Thatch Valley, and no resident population in the area that might be affected by aircraft operations. As with Old Quaw, the use of this area for eco-tourism has been discussed as a possible objective.

The main disadvantage to the Thatch Valley site is that it would be extremely expensive to develop (Gibb estimated EC$ 394M for an 1100m runway airport on this site).

7.0 EVALUATION OF ALTERNATIVE SITES

An evaluation of the three sites described in Section 6 was carried out using a multi-criteria system of evaluation. Also included in the evaluation was the Gerald's Bottom proposal, based on the 500m maximum runway length.

7.1 Evaluation Methodology

The methodology for evaluation involved defining six main criteria, three of which were also identified as having sub-factors. The four sites were then scored against the criteria. To determine an overall evaluation score for the sites, each criterion was assigned a weight, as were the sub-factors. By applying the weightings against the scores awarded for each alternative, a total evaluation score was obtained for each of the four alternatives. This process was carried out with an initial set of weightings, and both a score, and a rank ordering of preference, was obtained for the sites. Following this, in order to test for bias in the weightings, and for the possible influential effect of one or two specific criteria, a series of sensitivity tests was carried out. In these, the weightings that had been initially applied were changed for some tests, while for others one of the six criteria was set to zero, to test whether the result was sensitive to only one of the chosen criteria. By carrying out sensitivity tests on the evaluation, a set of evaluation results could be obtained and reviewed, and the consensus put forward as the evaluation result.

7.2 Evaluation Criteria

Criteria used for evaluation of the four sites were selected on the basis of their importance to the selection of a suitable airport site. In previous evaluations the aeronautical factors were not highlighted, even though the nature of some of the sites and the issues cited from time to time would suggest that the aeronautical feasibility of the site was of high importance.

For the evaluation carried out in this study, the following criteria were applied:

1. Aeronautical Conditions
   - Flight Operational Safety and the Obstacle Environment
   - Runway Orientation Relative to Wind
   - Potential for Wind Turbulence
   - Safety of the Runway Environment

2. Ability of the Site to Accommodate Long-Term Aviation Requirements and Larger Aircraft

3. Airport Construction
   - Extent of Earthworks and Probable Cost Implications
   - Ease or Difficulty of Construction

4. Availability of Access / Extent of Access construction

5. Social Impact
   - Aircraft Noise Impact
   - Impact on Local Residents / Population Displacement
   - Conflicting Land Use Requirements and Commitments

6. Environmental Impact

7.3 Results of the Evaluation

Several evaluations were carried out under the conditions described. The final result showed the following scores and rank ordering of preference:

Site Evaluated	Evaluation Score	Evaluation Score Indexed on Highest Scored Option	Rank Order of Preference
Gerald's Bottom	0.60	66.7%	4
Blake's Estate	0.90	100%	1
Old Quaw	0.70	77.8%	2
Thatch Valley	0.69	76.7%	3

In the evaluation, the Blake's Estate site was found to score highest by a considerable margin over the next two lower-ranked options. In second place, in rank order of preference, was the site at Old Quaw, with the Thatch Valley site scoring close third. The Gerald's Bottom site was consistently evaluated in fourth position.

The Blake's Estate site scored well in all evaluation tests, due mainly to its suitability for aviation, especially for the long-term, and its rather lower earthworks implications compared to the more difficult sites in the north of the island. Gerald's Bottom scored low due to its inability to meet long term airport needs, its potential social impact due to airport development, and its perceived safety environment for aviation. The other two sites were almost too close to call, as each has a differing degree of long-term suitability, but both are more costly to construct relative to Blake's Estate, and both are inferior sites by comparison.

As a result of the evaluation, the site at Blake's Estate was concluded to be best available under the circumstances. In the event of the Blake's Estate site being unavailable, the next highest ranked alternative, Old Quaw, would represent the next ranked site.

8.0 CONCLUSIONS

This study of issues, relating to the development of the airstrip at Gerald's Bottom, and the accompanying assessment of alternative airport sites on Montserrat, has led to the following conclusions

1. There is a need for a firm strategy to be adopted by the Government of Montserrat towards provision of an airport that can accommodate the longer-term air transport needs of the island. Five years have now passed since the initial consultant's study on airport requirements and, in the meantime, a suitable long-term option has not been reserved. The most suitable site outside the volcanic exclusion zone, at Blake's Estate, is the same one that was identified in 1997. However, recent encroachment by development on this site may now preclude its use for an airport. Any other option would either result in much higher costs being incurred, and possible operational restrictions of the airports (Old Quaw or Thatch Valley), or in substantial social impact (Gerald's Bottom).

2. The presently proposed project for a "temporary airstrip" at Gerald's Bottom is to a degree of engineering and investment that could render this a permanent facility. As such, it carries the risk that this may be the only airport investment that will be made by government, unless there are guarantees of further funding for the permanent airport solution. If the temporary airstrip at Gerald's Bottom cannot be extended, as seems to be the case, then another site will be required elsewhere within about 5 years, and capital sunk into the temporary airstrip will be lost. There is considerable merit in opting to invest in

development of an airstrip on a site that can accept further expansion as a long-term facility, even if the initial phase of that development results in construction of a relatively short runway for immediate needs.

3. The proposal to construct an airstrip of 500m in length at Gerald's Bottom, based on the performance specification of an aircraft that has been out of production for 14 years, cannot be regarded as forward-looking. With airlines in the region phasing out the Twin Otter, on which the runway design is to be based, the island will be dependent upon those remaining airlines that will continue to use this aircraft, or on the use of smaller 6 to 9 passenger aircraft, which are also becoming obsolete. Withdrawal of the Twin Otter can be anticipated over the coming 5 to 8 years, but passenger airlines can be expected to replace these aircraft sooner, due to a need to upgrade services and airline image. Within that time period, a new airport will be necessary for Montserrat, and this will have to be capable of accommodating not only those aircraft that will replace the Twin Otter, but also those aircraft that the airlines will be operating on inter-island services. For the most part, this means that island airports will need to accommodate aircraft types ranging from Dornier 228, up to DHC-8 or ATR-42 in size, because these will be the types in service with the airlines.

4. Review of the proposal by SEA-Aeroporti Di Milano for a 500m airstrip at Gerald's Bottom, designed for the Twin Otter, suggests that the design may have overlooked factors that influence the selection of a safe runway length.

   For instance, the study did not apply the actual elevation and reference temperature for Gerald's Bottom in the calculation of the runway length, resulting in an underestimate of runway length required by the critical aircraft. Nor was the amount of runway lost to turn an aircraft, prior to take-off, taken into account in the operational performance calculations.

   A major omission in the specification of runway requirements was found in that the runway proposed for construction did not allow for the aborted take-off condition, and therefore did not plan for the runway distances required under an emergency situation. These are the distances required for accelerate-stop, in which to bring an aircraft to a safe stop following an engine failure in the take-off run or, alternatively, to permit the aircraft to take-off with one engine inoperative. In the case of the Twin Otter, both distances are well in excess of 500m. As a result, the runway length proposed was too short to protect for the emergency take-off situation, and too short for the aborted take-off condition as well.

5. Examination of the plan for the proposed runway at Gerald's Bottom indicates that the runway strip will only just fit into the limits of the flat area of the site. As pointed out in Item 4 above, the plan does not provide for the emergency distances

required for the design aircraft, where take-off has to be aborted, or made with only one engine operating. Should either of these two conditions be encountered, or where a landing occurs too far down the runway, and at a higher speed than normal, an aircraft would run off the end of the runway. At Gerald's Bottom, such an overrun would take place on the east end of the runway, where the end of the strip would lie close to the top of a steep ravine, which falls away some 50 to 70m to the Queshie Spring. This ravine is a serious hazard, since an aircraft overrunning the end of the runway would travel down into the ravine, and likely incur structural damage, with possible risk of fire and consequent loss of life. Without any protection for the emergency stopping condition, and for runway overrun, the presence of a deep ravine immediately off the end of the runway strip can only be classed as dangerous. This is a clear and well-known hazard for development of a runway at Gerald's Bottom, and an aircraft accident involving an overrun into the deep ravine, with consequent hull destruction, injury and possible loss of life, could render the Government, and other parties to the cause of the accident, liable for damages.

6. A review and assessment has been made of three alternative "greenfield" sites, as well as the limited site at Gerald's Bottom, all of which are outside the volcanic exclusion zone. All of these sites have been considered in the past as possible sites for an airport. The greenfield sites evaluated were at Blake's Estate, Old Quaw, and Thatch Valley. The Gerald's Bottom site was evaluated on the basis of the conclusions of the Mott and SEA-ADM studies that this site could not be developed beyond the proposed 500m runway.

   In the assessment, a site at Blake's Estate was found to be the best of the three, and offered the ability to accommodate a runway of 1100m, and the possibility of instrument operations. While considerable earthworks were noted from previous studies as being required to create an airport, this was judged to be rather less than would be the case for either of the two other sites.

   A clear preference for development of the Blake's Estate site resulted from the evaluation. It is noted, however, that incompatible development is already taking place on, or near to, the Blake's Estate site, and this could jeopardise its development for an airport.

   In the evaluation, the site at Old Quaw scored well below that of Blake's Estate, but was ranked second, followed closely in third place by the site at Thatch Valley. The proposed development of a 500m runway at Gerald's Bottom, when evaluated against the other three sites, all of which offered a long-term capability, scored well below the other three sites, and was ranked in fourth place.

7. Of the two sites assessed in the north of the island, both would involve substantial earthworks to develop. Both appear to be incapable of development for anything other than a visual airport. Even the visual safeguarding requirements of ICAO Annex 14 may not be met with respect to the transitional surfaces on the landward side of the sites, against the sides of Silver Hill. As a result, a compromise would likely be necessary in design, and a dispensation required for licensing for commercial operations. In both cases, Silver Hill would be a hazard for aviation, and this may well preclude night operation of an airport at either of these sites.

8. With respect to the candidate site at Old Quaw, the maximum safe runway length that could be made available is 920m, and this would allow for protection of the runway overrun situation, which is very necessary due to the cliff top location of the airport site. At 920m, a runway on this site could support operations by larger aircraft up to DHC-8-100 without restriction, and DHC-8-300 aircraft at payloads of up to 80%. To develop an airport at Old Quaw, considerable earthworks would be involved, although judging from the contours of the site, this is expected to be less than would be encountered at Thatch Valley.

   In the evaluation of sites, the Old Quaw site was ranked second after Blake's Estate. Its positive features are that it can support a longer runway than appears to be possible at Gerald's Bottom, and this would therefore ensure that the longer term air access needs of the island could be accommodated to a much better degree. In addition, development of the site would not affect local residents or result in social disruption, and there are no conflicting uses for the site, other than an interest in its potential for eco-tourism.

   Its negative features lie in the site preparation effort, possible violations of ICAO Annex 14 safeguarding standards, a present lack of road access and utilities, and the possible wind turbulence effect under strong winds due to updrafts near the cliffs off the end of the runway.

   On balance, in the event that the Blake's Estate site cannot be released for construction of an airport, the site at Old Quaw, although not ideal, and possibly subject to operational restrictions, would be the next option for consideration. But before a firm decision can be made along these lines, further investigation would be needed, and some preliminary engineering design done to establish the optimum site profile. Once the site grading requirements are established, any infringement of the ICAO Annex 14 surfaces could then be discussed with the Department of Civil Aviation (OECS) to determine the acceptability of the proposed design, as well as dispensations required for licensing, and any aeronautical restrictions or other measures that would need to be applied to ensure safety of aviation.

9. The site suggested in earlier studies at Thatch Valley was ranked third in the evaluation. This site has the advantage that it could accommodate long term airport development. A runway could be constructed on the site to 1100m, and even extended further to 1300m if necessary. Because of cliffs on the east of the site, a runway would have to be set back sufficiently far to the west of the cliff edge, in order to protect for a runway overrun. This is very necessary as the eastern side of the site is bounded by sheer cliffs rising 76m above the sea.

   Another positive feature of the site is that it is free from conflicting land use pressures, again with the exception of a local interest in the area for eco-tourism.

   Negative features of the Thatch Valley site as an airport, are the very extensive earthworks that would clearly be necessary, the need for road access and utilities, and the likely inability for the site to meet ICAO Annex 14 standards for transitional surface safeguarding on the south (landward) side of a runway. As with the Old Quaw site, since a design compromise would probably need to be adopted for the transitional surface on the south side of the runway, further investigation would be necessary, and preliminary plans discussed with the Department of Civil Aviation (OECS) to ensure that the necessary dispensations for Annex 14 violations might be granted, and under what conditions, or operational restrictions.

9.0 OPTIONS FOR AIRPORT DEVELOPMENT

Based on the assessment and evaluation of alternative sites, there is a clear preference for development of the Blake's Estate site, and this is viewed as superior to any other. The two sites in the north of the island, while ranked second and third, are less suitable for a long-term airport development, and may have difficulties in meeting licensing requirements due to nearby terrain obstacles. Operational restrictions might then be applicable. The site at Gerald's Bottom, currently intended as a temporary airstrip, but for which the planned investment exceeds the minimum level expected for a temporary facility, has been found to be unsuitable by previous consultants, and this consensus is accepted. As things stand, there is somewhat of an impasse, and a way forward needs to be identified, that will suit the longer-term airport needs of the community, and the need to enable air access by residents and visitors.

There are essentially only three paths that can be followed:

1. No Action to Develop a Long-Term Airport

Proceed with construction of a paved airstrip at Gerald's Bottom, to operational criteria for small aircraft, for which the strip can be made safe (i.e. BN Islander and smaller aircraft types, rather than Twin Otter). This would be constructed on the basis that it would remain in service for light aircraft for

several years to come, in the hopes that the volcano would, one day, become dormant, so that the Bramble Airport might be re-opened;

2. Blake's Estate Available

If Blake's Estate can be confirmed as being available for airport construction, and that other land uses would have a lower importance in view of the special requirements for airport development, then the following approach would be recommended:

- Construct an initial runway of 700m to 799m on the Blake's Estate site, based on ICAO Code 1B, but with earthworks formation to ICAO Code 2C criteria, to enable later expansion of the airport and extension of the runway;

- Design for, and protect, the runway approaches and take-off areas for Code 2C instrument non-precision criteria;

- Relocate the Football pitch and stadium to another location where it would not conflict with the airport operations, with Gerald's Bottom being one possible site;

- Later, and depending on air carrier need to use the airport with larger aircraft, extend the runway to 1100 to 1199m.

3. Blake's Estate Unavailable

If Blake's Estate is unavailable for use as an airport, then the next preferred site would have to be adopted as the site for long-term development of an airport. Subject to confirmation of its ability to meet obstacle safeguarding requirements for licensing, or be granted dispensation, the preference would be to develop an initial runway at Old Quaw. This option would, however, have a longer lead time to construct, due to the more extensive site preparation, and an interim temporary grass airstrip might therefore be needed at Gerald's Bottom for use by light aircraft. The following is an approach to development of this option that might be considered:

- Initiate earthworks construction at Old Quaw based on an earthworks formation and obstacle safeguarding for an ultimate Code 2C runway.

- Construct an initial runway at Old Quaw at 700m to 799m based on Code 1B criteria;

- When the initial runway at Old Quaw is completed, decommission the helicopter pad at Gerald's Bottom and transfer aviation activity to old Quaw;

- Extend the runway at Old Quaw to 920m as required based on market and airline operational needs.

If the "No Action" approach is unacceptable, and this would appear to be the case, then a decision must be made as to whether the Blake's Estate site can be made available, or not. Depending on this decision, the most appropriate path can then be selected, and funding sought for development of the permanent airport.