RUNWAY FRICTION CHARACTERISTICS EVALUATION

Diego Garcia, BIOT

June 2004

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13. ABSTRACT *(Maximum 200 words)*

A pavements surface effects team from HQ Air Force Civil Engineer Support Agency (AFCESA), at the request of CENTAF/SE, conducted a runway friction characteristics evaluation at Diego Garcia, BIOT, from 25-31 May 2004. The purpose of the evaluation was to determine the skidding and hydroplaning potential of the runway. Surface transverse/longitudinal slopes, texture depth, self-wetting coefficient of friction, and flood testing was accomplished for Runway 13/31 and the Parallel Taxiway. Based on the test results, the following recommendations are made:

1. Runway 13/31: Saw transverse grooves along the full length of the Runway.

2. Runway 13/31: At a minimum, grind the first 3,000 feet of the runway ends to increase surface texture.

3. Following grooving and grinding operations, reseal all joints. High joint seal distress is the most widespread distress.

4. Until grooving is accomplished, restrict runway to emergency operations for at least 23 minutes after a rain event.

5. If used as a runway, issue NOTAM indicating parallel taxiway is unsafe for operations under wet conditions.

14. SUBJECT TERMS

Pavement Surface Slopes	Grip Tester
Pavement Surface Texture	Hydroplaning
Pavement Surface Friction	Skid Resistance

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Final Report

RUNWAY FRICTION CHARACTERISTICS EVALUATION OF DIEGO GARCIA, BIOT

by

Major Ron Pieri, P.E.
SSgt Greg Welch

June 2004

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY
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I. INTRODUCTION

A. Scope:

1. A pavements surface effects team from HQ Air Force Civil Engineer Support Agency (AFCESA) conducted a runway friction characteristics evaluation at Diego Garcia, British Indian Ocean Territory (BIOT), from 25 – 31 May 2004. The overall purpose of this evaluation was to determine the runway surfaces' potential to contribute to a skidding or hydroplaning incident. The primary objectives of this evaluation were to:

a. Determine certain runway surface characteristics, such as slope and texture.

b. Conduct measurements of the runway surface coefficient of friction.

c. Assess the capability of the runway to drain excess water and recover its friction properties.

2. This report summarizes the methods used to collect data, presents the findings of the evaluation, and makes conclusions and recommendations based on analysis of the data. The results of this report can be used to:

a. Alert aircrews of the potential for skidding or hydroplaning problems through Flight Information Publication (FLIP) notices or other means.

b. Identify and program runway maintenance and repair requirements such as rubber removal and pavement texturing projects.

c. Support programming documents that justify major pavement restoration projects.

3. Data results are presented in four appendices to this report as described below.

Appendix	Description
A	Slope Measurements: Tabulates the slopes measured on the runway(s). The transverse and longitudinal slopes are measured every 500 feet.
B	Texture Measurements: Presents the texture depth for various runway features and rainfall intensities required to flood these features.
C	Self-Wetting Grip Tester Friction Data Plots: Contains friction plots for the entire length of the runway(s) and describes the guidelines for determining acceptable friction characteristics.
D	Flood Recovery Test Data: Presents flood recovery curves for 1,000-ft test sections.
E	Visual Estimation Of Rubber Deposits: Presents a method to determine rubber removal requirements based on visual inspections.

II. BACKGROUND DATA

A. General Description of Airfield: Primarily KC-135, KC-10, B-1, B-2, B-52, and transient aircraft use Runway 13/31. Runway 13/31 is 12,000 ft long by 200 ft wide and constructed of Portland Cement Concrete (PCC). The Parallel Taxiway is 12,000 ft long by 175 ft wide. It's keel section is PCC and shoulders are asphalt. A summary of the pavement information follows:

Runway	Length	Width	Interior Surface	Thresholds
13/31	12,000 ft	200 ft	PCC	PCC

Taxiway	Length	Width	Interior Surface	Thresholds
Parallel	12,000 ft	175 ft	PCC	PCC

B. Previous Evaluation: AFESC performed a friction evaluation in Nov 1990 and Naval Facilities Engineering command performed a friction evaluation in 1996.

C. Maintenance History: Rubber removal is performed every six months. Rubber build-up at the time of evaluation was light to medium in the touchdown areas.

III. TEST PROCEDURES

A. Slope Measurements:

1. The slope measuring equipment consists of an 8-ft aluminum level fitted with an electronic module to measure slopes to the nearest 0.1 percent.

2. Pavement surface transverse and longitudinal slopes were measured every 500 ft along the entire length of the runway. Transverse slopes were measured at 10 ft and 20 ft from the centerline, on both sides of the centerline. A single longitudinal slope was measured at the runway centerline. Good slopes promote drainage and reduce the hydroplaning potential. AFJMAN 32-1013, Volume 1 requires transverse slopes between 1 and 1.5% to promote good drainage.

B. Surface Texture Measurements:

1. A grease smear test was used to measure the texture depth of the pavement surface. The test equipment consists of 0.915 cubic inch (15 cc) of grease and a 4 in (10.16 cm) wide template in which the grease is evenly spread on the pavement surface. The volume of grease is then divided by the area of the smear to calculate the texture depth. The sum of the individual tests divided by the total number of tests yields the average texture depth (ATD) [Federal Aviation Administration Advisory Circular (FAA AC) 150/5320-12C].

2. Texture depth measurements were made at several locations to obtain a representative sampling of the pavement macrotexture. Macrotexture provides channels for bulk water drainage and is an important component in the overall friction properties of a pavement surface. Research has shown a strong potential for hydroplaning exists when the average texture depth (ATD) is less than 0.016 in (0.4 mm). Additional testing is required to determine the hydroplaning potential of surfaces with average texture depths between 0.016 and 0.036 inches. ATDs greater than 0.036 inches generally have a low potential for hydroplaning (Williams, 1975). A complete analysis of surface texture would ideally include an assessment of the surface microtexture, the fine asperities that pierce the remaining thin film of water and grip the aircraft tire. However, there is no accurate method to measure this characteristic.

C. Friction Measurements:

1. A Grip Tester was used to measure the runway surface friction. The Grip Tester is a three-wheel trailer, which measures friction by the braked wheel, fixed-slip principle. Its single measuring wheel fitted with a special smooth tread tire is mounted on an axle instrumented to measure both the horizontal drag force and the vertical load force. From these measurements, the dynamic friction reading is automatically calculated and transmitted to the data collection computer carried in the cab of the towing vehicle. This computer also calculates and stores the survey speed for each reading. An onboard self-wetting system regulates flow from a 150-gallon tank to nozzles that distribute a 0.04 in (1 mm) film of water beneath the smooth tire at testing speeds of 40 and 60 mph (FAA AC 150/5320-12C). The majority of the Grip Tester's weight is distributed over two drive wheels, which are fitted with patterned tread tires and mounted on a solid, stainless steel drive axle. This drive axle carries a sprocket of 27 teeth and the cantilever axle on which the measuring wheel is mounted carries a sprocket of 32 teeth. A transmission chain links the two axles. This transmission system continuously brakes the measuring wheel, forcing it to slip. This slipping wheel and the weight of the Grip Tester cause minute bending movements in the cantilever axle that are measured by two pairs of strain gauges

mounted on its vertical and horizontal faces. The signals from these strain gauges are processed by the signal-processing unit mounted on the top of the Grip Tester and are then transmitted to the data collection computer. Distance and speed are calculated from a proximity sensor activated by a wheel with 20 square teeth mounted on the drive axle.

2. Testing Modes:

a. Self-wetting: Friction measurements were made along the entire runway length employing the Grip Tester self-wetting system. Test runs were conducted 5 ft from both sides of the runway centerline at 40 and 60 mph. A separate 40-mph test was also conducted on the less trafficked pavement along the right edge of the runway. A 60-mph test was conducted on the less trafficked pavement along the left edge of the runway. These measurements help to identify those areas of the runway pavement that are smooth due to poor texture, excessive traffic wear, aggregate polishing, and/or surface contaminants such as rubber deposits and oil/fuel spills. The measured friction values are compared to Federal Aviation Administration (FAA) guidelines to determine if corrective action is required. These standards are adopted from FAA AC 150/5320-12C, “Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces.” The guidelines apply only to wet runway surfaces. They do not apply to ice or snow covered surfaces. See Appendix C for additional test result interpretation guidelines.

Friction Level Classification	Grip Tester 40 mph	Grip Tester 60 mph
Action	0.43	0.24
Planning	0.53	0.36

b. Runway Flooding: Runways may have different feature characteristics on the pavement, such as depressed areas or texture changes, which may pond or hold excess water during periods of moderate to heavy rainfall. Because of this, water may exceed the depth used by the self-wetting system and the actual traction capacity of the pavement in these areas may be less than that determined by the self-wetting system. Whereas the self-wetting test uses only enough water to evaluate the requirement for maintenance of the surface texture, the flooding test oversaturates the texture to evaluate the runway's ability to drain excess water. Therefore, a specific 1,000 ft test section on the runway was selected for further study of the drainage properties using the following procedures:

i. A dry Grip Tester run was conducted to establish the maximum friction available for aircraft braking performance.

ii. A water tanker discharged water on the test section.

iii. Continuous Grip Tester runs were initiated immediately following the pass of the water truck and continued until the friction values exceeded the planning level or the time exceeded 30 minutes. The test section runs were conducted at a speed of 40 mph in one direction and at 60 mph in the opposite direction.

iv. An average Mu value for the 1,000 ft section was determined for each test run and plotted versus time. This plot forms a friction-recovery curve and clearly illustrates the flood recovery characteristics of the runway surface.

c. Ground Vehicle Friction Correlation: The following chart provides a correlation between the Grip Tester and various friction testing equipment:

Friction Index and Friction Rating Scales

Friction Rating	Friction Index 65 kph (40 mph) Nominal Test Speed, Unless Noted [10]									
	RCR[1]	GripTester[2]	JBI[3]	Mu-Meter	Surface Friction Tester[4]	Runway Friction Tester[5]	Bv-11 Skiddo-Meter[4]	Decel Meters[6]	Locked Wheel Devices[7]	IMAG[8]	ICAO Index[9]
Good	>17	>0.49	>0.58	>0.50	>0.54	>0.51	>0.59	>0.53	>0.51	>0.53	5
Fair	12-17	0.34–0.49	0.40–0.58	0.35–0.50	0.38–0.54	0.35–0.51	0.42–0.59	0.37–0.53	0.37–0.51	0.40–0.53	3–4
Poor	≤11	≤0.33	≤0.39	≤0.34	≤0.37	≤0.34	≤0.41	≤0.36	≤0.36	≤0.40	1–2

Notes:

1. RCR (runway condition rating): Decelerometer reading x 32 obtained at 40 kph (25 mph)
2. Measurements obtained with smooth ASTM tire inflated to 140 kPa (20 psi)
3. JBI: James Brake Index obtained at 40 kph (25 mph)
4. Measurements obtained with grooved aero tire inflated to 690 kPa (100 psi)
5. Measurements obtained with smooth ASTM 4 in x 8.0 in tire inflated to 210 kPa (30 psi)
6. Decelerometers include Tapley, Bowmonk, and electronic recording decelerometer at 40 kph (25 mph)
7. ASTM E-274 skid trailer and E-503 diagonal-brake vehicle equipped with ASTM E-524 smooth test tires inflated to 170 kPa (24 psi)
8. IMAG: Trailer device (manufactured in France) operated at 15% slip; grooved PIARC tire inflated to 690 kPa (100 psi)
9. ICAO: International Civil Aviation Organization index of friction characteristics
10. A wet runway produces a drop in friction with an increase in speed. If the runway has good texture, allowing the water to escape beneath the tire, then friction values will be less affected by speed. Conversely, a poorly textured surface will produce a larger drop in friction with an increase in speed. Friction characteristics can be further reduced by poor drainage due to inadequate slopes or depressions in the runway surface.

IV. TEST RESULTS

A. Slope Measurements:

1. Slope measurement results are illustrated in Appendix A. A positive transverse slope indicates that water will drain away from the runway centerline. A positive longitudinal slope indicates that water will drain toward the secondary runway approach end.

a. Runway 13/31: The runway is 200 feet wide. The runway is crowned from the center to the outer edges with slopes ranging from 0.3 to 1.9% and 85% of the transverse slopes are greater than or equal to the 1% recommended minimum. The longitudinal slopes range from –0.5 to 0.3%.

b. Parallel Taxiway: The taxiway is 175 feet wide. The taxiway is crowned from the center to the outer edges with slopes ranging from –1.7 to 1.7% and 55% of the transverse slopes are greater than the 1% recommended minimum. The longitudinal slopes range from -0.7 to 0.6%.

B. Texture Depth: The average texture depth (ATD) measurements and rainfall flooding rates for the runway surfaces are contained in Appendix B.

1. Texture depths were measured at several locations on the pavement surface, usually near the centerline in the heavily trafficked area, and also along the edge to make a comparison between high and low traffic pavement. Average texture depths greater than 0.016 inches are considered acceptable. On Runway 13/31 the measured texture depths are shown on page B-1 and the Parallel Taxiway is shown on page B-2. Runway 13/31 ATD ranged from 0.0032 to 0.0199 inches with an overall average of 0.0092 inches. The Parallel Taxiway ATD ranged from 0.0052 to 0.0195 inches with an overall average of 0.0073 inches. The ATD for the Runway and Primary Taxiway are approximately 50% of the accepted minimum.

2. A mathematical model was used to determine the rainfall intensity necessary to cause flooding on the runways. Keep in mind that the model does not consider weather effects like temperature, wind, and evaporation rates, which can significantly change drainage characteristics. The predicted rainfall rate required to flood the runway macrotexture is listed on pages B-3 and B-4 for Runway 13/31 and the Parallel Taxiway, respectively. This model indicates that rainfall rates between about 0.04 to 0.23 inches per hour could flood Runway 13/31 and rainfall rates between about 0.03 to 0.16 inches per hour could flood the Parallel Taxiway.

C. Grip Tester Friction Data:

1. The measured friction values are contained in Appendix C. The parameters set by FAA AC 150/5320-12C for action and planning friction levels are listed on page C-1. Pages C-3 and C-5 are similar to C-2 and C-4. However, these charts compare just the test data from left and right of centerline. The edge section was removed to make the charts easier to read.

Runway 13/31: The measured friction values for the runway are illustrated on page C-2 and C-3. Unless otherwise stated, distance remaining values are referenced from the 31 end. The values at the 40-mph testing speed at most locations hover between the planning and action levels or below the action level. The measured values on the left and right of centerline show that the runway surface exhibits significant potential for hydroplaning. Both touchdown areas and most of the runway interior display friction levels below the action level on the right, left, or both testing sides. The highest friction levels were at 8,000 to 5,000 distance remaining where values oscillated between the planning and action level. The 60-mph test data shows that either one or both sides of the centerline are below the planning level for the entire length of the Runway at all but four points on the chart. Either one or both 60-mph tests show that the data falls beneath the action level for more than 80% of the Runway surface. The edge testing stays above the planning level for the majority of the runway but hovers between the planning and action level in several areas. The edge testing suggests that significant polishing has occurred due to aircraft traffic, rubber removal operations, and soft aggregate in the concrete. **The analysis shows that corrective action should be taken immediately**.

Parallel Taxiway: Since the parallel taxiway does not have overruns, testing started at 11,500 feet and ended at 500 feet from the north end. The measured friction values for the Parallel Taxiway are illustrated on page C-4 and C-5. The values at the 40-mph testing speed are significantly low, and range from 0.2 to the action value of 0.43. Few sections actually reach the zone between the planning and action level. 60-mph tests show the same trend and only reach above the action level during the last 1,000 feet, attributed to the operator slowing the vehicle, not because the pavement had better friction characteristics. The edge testing for both testing speeds mimic the centerline tests showing degradation of surface friction has not occurred. The Parallel Taxiway has poorer friction characteristics than the Runway and should not be used when the surface is wet except under emergency conditions. **If used as a runway, a NOTAM should be issued to restrict use during wet conditions**.

2. The friction recovery curves for the flooded test section are contained in Appendix D. Three tests were done for Runway 13/31 and two for the Parallel Taxiway. The average Mu value for the section was plotted versus time to produce the curves. At the time of testing, the ambient temperature was 80°F and the weather was partly cloudy to sunny skies.

Flood Test A for Runway 13/31 was located 1,500 to 2,500 feet from the 31 end of the runway. The results are illustrated on page D-1. The test section recovered to above the action level in 13 minutes at 40 mph and 6 minutes at 60 mph. Flood Test B was located 5,000 to 6,000 feet from the 31 end of the Runway. The results are illustrated on page D-2 and the test section recovered to above the action level in 5 minutes at 40 mph and 3 minutes at 60 mph. Flood Test C was located 10,000 to 11,000 feet from the 31 end of the Runway. The results are illustrated on page D-3. The test section recovered to above the action level in 15 minutes at 40 mph and 14 minutes at 60 mph. Flood Test C governs the minimum requirement for this Runway; aircraft should not operate on the Runway surface for at least 15 minutes following a high-intensity rainfall event. A more conservative value comes from Flood Test A, where the section recovers to the planning level in 23 minutes.

Flood Test A for the Parallel Taxiway was located 8,000 to 9,000 feet from the 31 end and the results are shown on D-4. The test section recovered to above the action level in 7 minutes at 40 mph and 3 minutes at 60 mph. Flood Test B for the Parallel Taxiway was located 3,000 to 4,000 feet from the 31 end and the results are shown on D-5. The test section recovered to above the action level in 6 minutes at 40 mph and almost immediately at 60 mph. The minimum amount of time for aircraft operations on the Parallel Taxiway is 7 minutes, though a more conservative value comes from Flood Test A showing the surface recovers to the planning level in 11 minutes.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions:

1. Runway 13/31: The surface friction is below the minimum threshold for the majority of the runway. Both touchdown areas and much of the interior section of the Runway have poor friction characteristics. The only section that showed fair friction performance was the section 4,000 to 6,000 feet from the 31 end. The lowest 500-foot average was at 1,000 to 1,500 from the 31 end with a MU value equal to 0.19. This correlates to a RCR of 7.

2. Parallel Taxiway: This surface has a lower average texture depth and displays poorer friction characteristics than the Runway. It should not be used in wet weather conditions. The lowest 500-foot average was at 3,000 to 3,500 feet from the 31 end with a MU value equal to 0.25. This correlates to a RCR of 9.

B. Recommendations:

1. Runway 13/31: Saw transverse grooves along the full length of the Runway. Standard FAA groove configuration is ¼ inch in depth, ¼ inch in width, with 1½ inch center-to-center spacing. The grooves should be terminated within 10 feet of the runway edge and the grooves shall not be closer than 3 inches or more than 9 inches from transverse joints and not closer than 3 inches from longitudinal joints. This spacing will eliminate damage to joint sealant and prevent premature joint spalling.

2. Runway 13/31: At a minimum, grind the first 3,000 feet of the runway ends. Grinding will improve the overall surface texture and increase the average texture depth of the runway.

3. Following grooving and grinding operations, reseal all joints. High joint seal distress is the most widespread distress on the runway.

4. Runway 13/31: Until grooving is accomplished, recommend runway operations are restricted to emergency operations for at least 23 minutes following a rainfall event.

5. Parallel Taxiway: If used as a runway, a NOTAM should be issued restricting use under wet conditions.

REFERENCES

AFJMAN 32-1013, VOLUME 1. (1981) *Civil Engineering Programming Airfield and Heliport Planning Criteria,* Departments of the Air Force, the Army, and the Navy, 12 May 1981.

ASTM E670-94 (1987). “Standard Test Method for Side Force Friction on Paved Surfaces Using the Mu-Meter,” *1995 Annual Book of ASTM Standards: Road and Paving Materials; Paving Management Technologies*, Vol. 04.03, American Society for Testing and Materials.

FAA Advisory Circular AC 150/5320-12C (1997). *Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces*, US Department of Transportation, Federal Aviation Administration, 18 March 1997.

International Civil Aviation Organization (ICAO) (1990). *International Standards and Recommended Practices - Aerodromes,* Annex 14, Vol I, 1st Ed., ICAO, Montreal, Canada.

International Civil Aviation Organization (1994). *Airport Services Manual, Part 2, Pavement Surface Conditions,* Third Edition - 1994, (Doc 9137-AN/898), ICAO, Montreal, Canada.

NASA SP-5073 (1968). *Pavement Grooving And Traction Studies*, National Aeronautics and Space Administration, Langley Research Center, November 1968.

Air Force Civil Engineering Center, (1975). *Analysis of the Standard USAF Runway Skid Resistance Tests*, Technical Report No. AFCEC-TR-75-3, May 1975.

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Diego Garcia Runway, BIOT

SLOPE MEASUREMENTS

13

0.6	0.9	0.6	0.6	12000
0.5	0.9	0.9	0.6	
0.4	0.5	0.5	0.3	11000
1.4	1.5	1.4	1.7	
1.4	1.6	1.5	1.7	10000
1.3	1.3	1.5	0.9	
1.4	1.8	1.5	1.2	9000
1.6	1.6	1.5	1.2	
1.5	1.6	1.6	1.2	8000
1.3	1.6	1.4	1.4	
1.1	1.6	1.5	1.0	7000
1.2	1.2	1.5	1.6	
0.8	1.6	1.5	1.3	6000
1.2	1.4	1.7	1.3	
1.2	1.7	1.6	1.6	5000
1.5	1.2	1.5	1.5	
1.8	1.5	1.6	1.3	4000
1.3	1.6	1.6	1.5	
1.5	1.6	1.4	1.4	3000
1.4	1.5	1.5	1.4	
1.4	1.6	1.5	1.2	2000
1.9	1.4	1.7	1.3	
1.6	1.4	1.7	1.4	1000
1.3	1.6	1.5	1.1	
1.9	1.5	1.8	1.7	0

31

TRANSVERSE SLOPE

1. ALL TRANSVERSE SLOPE MEASUREMENTS WERE TAKEN WITHIN 20 ' (6.1M) 0F THE CENTERLINE.
2. POSITIVE SLOPE VALUES INDICATE DRAINAGE AWAY FROM CENTERLINE.
3. NEGATIVE SLOPE VALUES INDICATE DRAINAGE TOWARD CENTERLINE.

0.3	12000
-0.1	
0.2	11000
0.1	
-0.1	10000
0.0	
-0.2	9000
-0.1	
-0.2	8000
-0.2	
0.0	7000
0.0	
-0.1	6000
-0.2	
0.0	5000
0.0	
-0.1	4000
-0.1	
-0.2	3000
0.0	
-0.1	2000
-0.2	
0.0	1000
-0.5	
0.1	0

LONGITUDINAL SLOPE

1. ALL LONGITUDINAL SLOPE MEASUREMENTS WERE TAKEN AT CENTERLINE.
2. POSITIVE SLOPE VALUES INDICATE DRAINAGE TOWARD SECONDARY END OF RUNWAY **13**.
3. NEGATIVE SLOPE VALUES INDICATE DRAINAGE TOWARD PRIMARY END OF RUNWAY **31**.

Diego Garcia Taxiway, BIOT

SLOPE MEASUREMENTS

13

1.7	-1.7	1.1	1.4	12000
1.4	0.8	0.9	1.4	
0.8	1.6	1.7	0.5	11000
0.9	1.2	1.0	1.2	
1.2	1.0	0.9	1.0	10000
1.4	1.0	0.8	1.1	
1.0	0.7	0.6	0.8	9000
1.5	0.8	0.9	1.1	
1.2	0.8	0.7	1.2	8000
1.0	0.8	0.0	1.3	
1.3	1.1	0.8	1.2	7000
1.5	1.4	0.5	0.8	
1.3	1.4	0.8	1.2	6000
1.3	0.7	0.5	0.9	
1.1	1.0	1.0	0.6	5000
1.2	0.7	0.9	0.8	
1.5	1.2	0.9	1.2	4000
1.0	1.1	0.8	1.0	
1.0	1.1	0.4	1.3	3000
1.1	0.7	1.0	1.2	
0.8	1.2	0.7	0.8	2000
0.6	0.5	1.0	1.2	
0.7	0.3	1.1	0.6	1000
1.0	1.0	0.8	0.7	
1.3	0.8	0.5	1.0	0

31

TRANSVERSE SLOPE

1. ALL TRANSVERSE SLOPE MEASUREMENTS WERE TAKEN WITHIN 20 ' (6.1M) 0F THE CENTERLINE.
2. POSITIVE SLOPE VALUES INDICATE DRAINAGE AWAY FROM CENTERLINE.
3. NEGATIVE SLOPE VALUES INDICATE DRAINAGE TOWARD CENTERLINE.

-0.1	12000
0.2	
0.3	11000
0.3	
-0.2	10000
0.2	
0.1	9000
0.2	
0.2	8000
0.0	
0.6	7000
-0.5	
0.2	6000
0.0	
0.2	5000
0.2	
-0.1	4000
0.1	
0.2	3000
-0.2	
0.1	2000
0.2	
0.0	1000
0.2	
-0.7	0

LONGITUDINAL SLOPE

1. ALL LONGITUDINAL SLOPE MEASUREMENTS WERE TAKEN AT CENTERLINE.
2. POSITIVE SLOPE VALUES INDICATE DRAINAGE TOWARD SECONDARY END OF TAXIWAY **13**.
3. NEGATIVE SLOPE VALUES INDICATE DRAINAGE TOWARD PRIMARY END OF TAXIWAY **31**.

Diego Garcia Runway 13/31

SURFACE TEXTURE MEASUREMENTS

LOCATION		PAVEMENT TYPE	SURFACE RUBBER	LENGTH OF 4" WIDE TEST STRIP		AVERAGE TEXTURE DEPTH (ATD)	
FT FROM PRIMARY END	FT FROM CENTER LINE			INCHES	MM	INCHES	MM
0	100R	PCC	NONE	14.00	355.6	0.0163	0.4152
1000	10R	PCC	LIGHT TO MEDIUM	11.50	292.1	0.0199	0.5054
1000	0	PCC	LIGHT TO MEDIUM	18.50	469.9	0.0124	0.3142
1500	0	PCC	MEDIUM	38.00	965.2	0.0060	0.1530
1500	10L	PCC	LIGHT TO MEDIUM	21.50	546.1	0.0106	0.2703
2000	10R	PCC	LIGHT TO MEDIUM	40.00	1016.0	0.0057	0.1453
2000	10L	PCC	LIGHT TO MEDIUM	51.00	1295.4	0.0045	0.1140
2500	10R	PCC	NONE	23.50	596.9	0.0097	0.2473
2500	10L	PCC	LIGHT TO MEDIUM	26.50	673.1	0.0086	0.2193
3000	10R	PCC	LIGHT	25.00	635.0	0.0092	0.2325
3000	10L	PCC	NONE	61.00	1549.4	0.0038	0.0953
4000	10R	PCC	NONE	24.00	609.6	0.0095	0.2422
4000	10L	PCC	NONE	17.00	431.8	0.0135	0.3419
5000	10R	PCC	NONE	20.00	508.0	0.0114	0.2906
5000	10L	PCC	NONE	17.00	431.8	0.0135	0.3419
6000	10R	PCC	NONE	30.00	762.0	0.0076	0.1937
6000	10L	PCC	NONE	18.00	457.2	0.0127	0.3229
7000	10R	PCC	NONE	29.00	736.6	0.0079	0.2004
7000	10L	PCC	NONE	19.00	482.6	0.0120	0.3059
8000	10R	PCC	LIGHT	50.00	1270.0	0.0046	0.1162
8000	10L	PCC	NONE	24.00	609.6	0.0095	0.2422
9000	10R	PCC	NONE	52.50	1333.5	0.0044	0.1107
9000	10L	PCC	NONE	29.00	736.6	0.0079	0.2004
10000	10R	PCC	LIGHT	37.00	939.8	0.0062	0.1571
10000	10L	PCC	LIGHT	71.00	1803.4	0.0032	0.0819
11000	10R	PCC	LIGHT	36.00	914.4	0.0064	0.1614
11000	10L	PCC	NONE	20.00	508.0	0.0114	0.2906

NOTE:

AN ATD < 0.016 INCHES HAS STRONG HYDROPLANING POTENTIAL

AN ATD > 0.016 INCHES BUT < 0.036 INCHES REQUIRES FURTHER TESTING FOR HYDROPLANING POTENTIAL

AN ATD > 0.036 INCHES HAS LOW HYDROPLANING POTENTIAL

Diego Garcia Taxiway, BIOT

SURFACE TEXTURE MEASUREMENTS

LOCATION		PAVEMENT TYPE	SURFACE RUBBER	LENGTH OF 4" WIDE TEST STRIP		AVERAGE TEXTURE DEPTH (ATD)	
FT FROM PRIMARY END	FT FROM CENTER LINE			INCHES	MM	INCHES	MM
0	10 L	PCC	NONE	11.75	298.5	0.0195	0.4947
500	10 L	PCC	NONE	34.00	863.6	0.0067	0.1709
750	10 R	PCC	NONE	36.00	914.4	0.0064	0.1614
1000	10 L	PCC	NONE	40.50	1028.7	0.0057	0.1435
1500	10 R	PCC	NONE	41.00	1041.4	0.0056	0.1418
2000	10 L	PCC	NONE	41.50	1054.1	0.0055	0.1401
2500	10 R	PCC	NONE	32.50	825.5	0.0070	0.1788
3000	10 L	PCC	NONE	31.50	800.1	0.0073	0.1845
4000	10 R	PCC	NONE	37.00	939.8	0.0062	0.1571
5000	10 L	PCC	NONE	44.00	1117.6	0.0052	0.1321
6000	10 R	PCC	NONE	42.00	1066.8	0.0054	0.1384
7000	10 L	PCC	NONE	37.00	939.8	0.0062	0.1571
8000	10 R	PCC	NONE	29.00	736.6	0.0079	0.2004
9000	10 L	PCC	NONE	31.00	787.4	0.0074	0.1875
9550	10R	PCC	NONE	36.00	914.4	0.0064	0.1614
10000	10 R	PCC	NONE	38.00	965.2	0.0060	0.1530
10500	10 L	PCC	NONE	25.00	635.0	0.0092	0.2325
11000	10 R	PCC	NONE	32.00	812.8	0.0072	0.1816

NOTE:

AN ATD < 0.016 INCHES HAS STRONG HYDROPLANING POTENTIAL

AN ATD > 0.016 INCHES BUT < 0.036 INCHES REQUIRES FURTHER TESTING FOR HYDROPLANING POTENTIAL

AN ATD > 0.036 INCHES HAS LOW HYDROPLANING POTENTIAL

Diego Garcia Runway, BIOT

RAINFALL (INCHES/HOUR) TO FLOOD THE AVERAGE PAVEMENT TEXTURE DEPTH

13

15FT	5FT	C/L	5FT	15FT	
0.05	0.14		0.11	0.05	12000
0.04	0.14		0.14	0.05	
0.04	0.09		0.09	0.03	11000
0.09	0.20		0.19	0.10	
0.09	0.21		0.20	0.10	10000
0.08	0.18		0.20	0.06	
0.09	0.23		0.20	0.08	9000
0.10	0.21		0.20	0.08	
0.09	0.21		0.21	0.08	8000
0.08	0.21		0.19	0.09	
0.07	0.21		0.20	0.07	7000
0.08	0.17		0.20	0.10	
0.06	0.21		0.20	0.08	6000
0.08	0.19		0.22	0.08	
0.08	0.22		0.21	0.10	5000
0.09	0.17		0.20	0.09	
0.10	0.20		0.21	0.08	4000
0.08	0.21		0.21	0.09	
0.09	0.21		0.19	0.09	3000
0.09	0.20		0.20	0.09	
0.09	0.21		0.20	0.08	2000
0.11	0.19		0.22	0.08	
0.10	0.19		0.22	0.09	1000
0.08	0.21		0.20	0.07	
0.11	0.20		0.23	0.10	0

31

NOTE: THIS IS THE AMOUNT OF RAIN IN INCHES PER HOUR REQUIRED TO CREATE A HIGH POTENTIAL FOR DYNAMIC HYDROPLANING.

Diego Garcia Taxiway, BIOT

RAINFALL (INCHES/HOUR) TO FLOOD THE AVERAGE PAVEMENT TEXTURE DEPTH

13

15FT	5FT	C/L	5FT	15FT	
0.07	0.16		0.11	0.06	12000
0.06	0.09		0.10	0.06	
0.04	0.15		0.16	0.03	11000
0.04	0.12		0.11	0.05	
0.05	0.11		0.10	0.05	10000
0.06	0.11		0.09	0.05	
0.05	0.08		0.07	0.04	9000
0.06	0.09		0.10	0.05	
0.05	0.09		0.08	0.05	8000
0.05	0.09		0.01	0.06	
0.06	0.11		0.09	0.05	7000
0.06	0.14		0.07	0.04	
0.06	0.14		0.09	0.05	6000
0.06	0.08		0.07	0.04	
0.05	0.11		0.11	0.03	5000
0.05	0.08		0.10	0.04	
0.06	0.12		0.10	0.05	4000
0.05	0.11		0.09	0.05	
0.05	0.11		0.06	0.06	3000
0.05	0.08		0.11	0.05	
0.04	0.12		0.08	0.04	2000
0.03	0.07		0.11	0.05	
0.04	0.05		0.11	0.03	1000
0.05	0.11		0.09	0.04	
0.06	0.09		0.07	0.05	0

31

NOTE: THIS IS THE AMOUNT OF RAIN IN INCHES PER HOUR REQUIRED TO CREATE A HIGH POTENTIAL FOR DYNAMIC HYDROPLANING.

GRIP TESTER SELF-WETTING
FRICTION MEASUREMENT PARAMETERS

A. Friction Deterioration Below the Planning Level for 500 Feet.
When the average Friction value is:
> .43 and < .53 at 40 mph AND > .24 and < .36 at 60 mph
for a distance of 500 ft, AND adjacent 500 ft segments are:
> .53 at 40 mph AND > .36 at 60 mph
no corrective action is required.

These readings indicate that the pavement friction is deteriorating but the situation is not within an unacceptable overall condition.
The area in question should be monitored closely by conducting friction surveys to establish the rate and the extent of friction deterioration.

B. Friction Deterioration Below the Planning Friction Level for 1000 Feet.
When the average Friction value is:
< .53 at 40 mph AND <.36 at 60 mph
For a distance of 1000 feet or more, conduct an extensive evaluation into the cause(s) and extent of the friction deterioration and **take appropriate corrective action**.

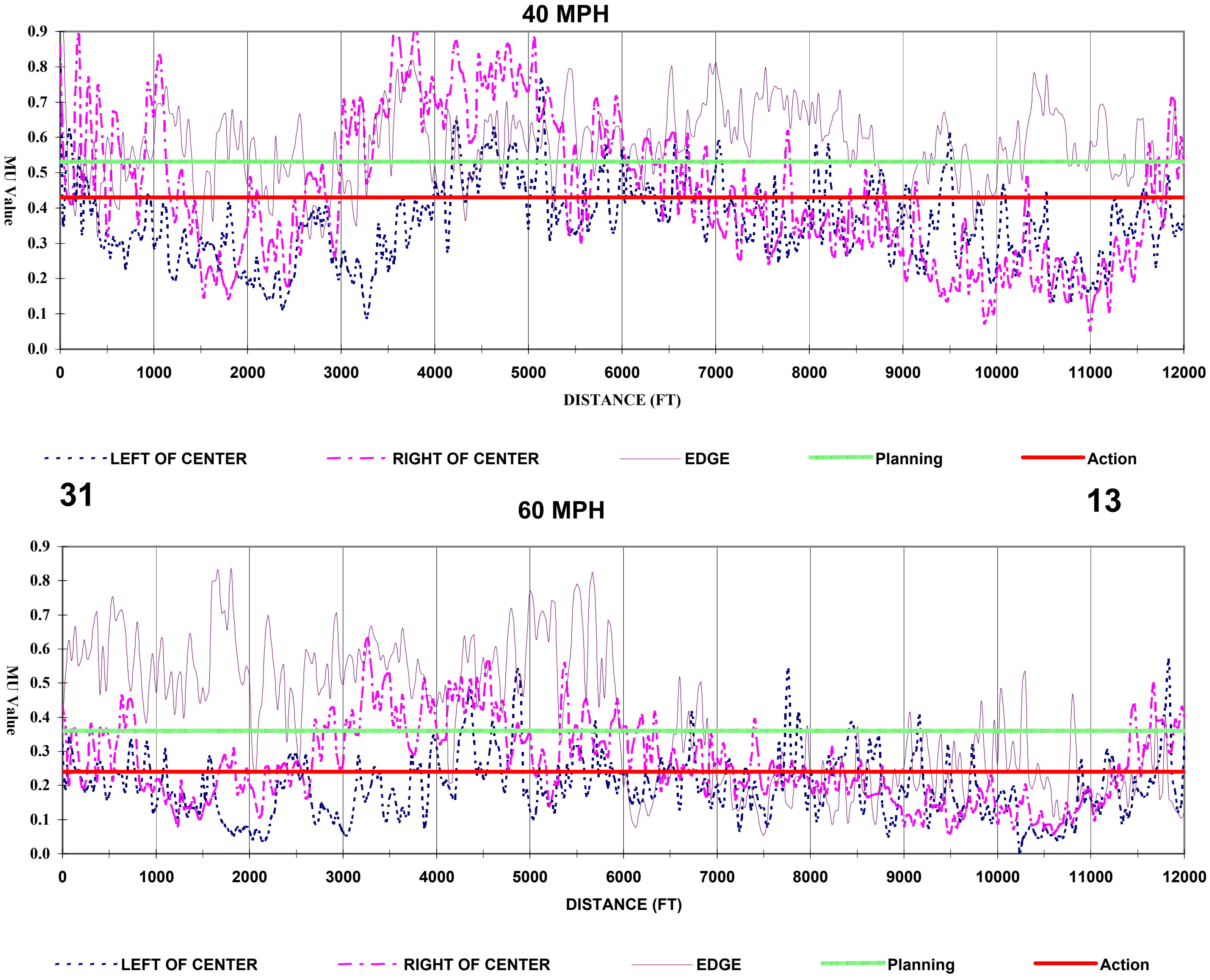
C. Friction Deterioration Below Action Friction Level.
When the average Friction value is:
< .43 at 40 mph AND < .24 at 60 mph
for a distance of 500 feet, AND the adjacent 500 ft segments are:
< .53 at 40 mph AND < .36 at 60 mph
Corrective action should be taken immediately after determining the cause(s) of the friction deterioration.
The overall condition of the entire runway pavement surface should be evaluated with respect to the deficient area before undertaking corrective measures.

D. New Design/Construction Friction Level.
For newly constructed runway surfaces that are either saw-cut grooved or have a porous friction course overlay, the average Friction value of the wet runway pavement surface for each 500 ft segment should be:
> .74 at 40 mph AND > .64 at 60 mph

NOTE: ALL MEASUREMENTS ARE ON WET PAVEMENT SURFACE CONDITIONS AS PER FAA AC 150/5320-12C.

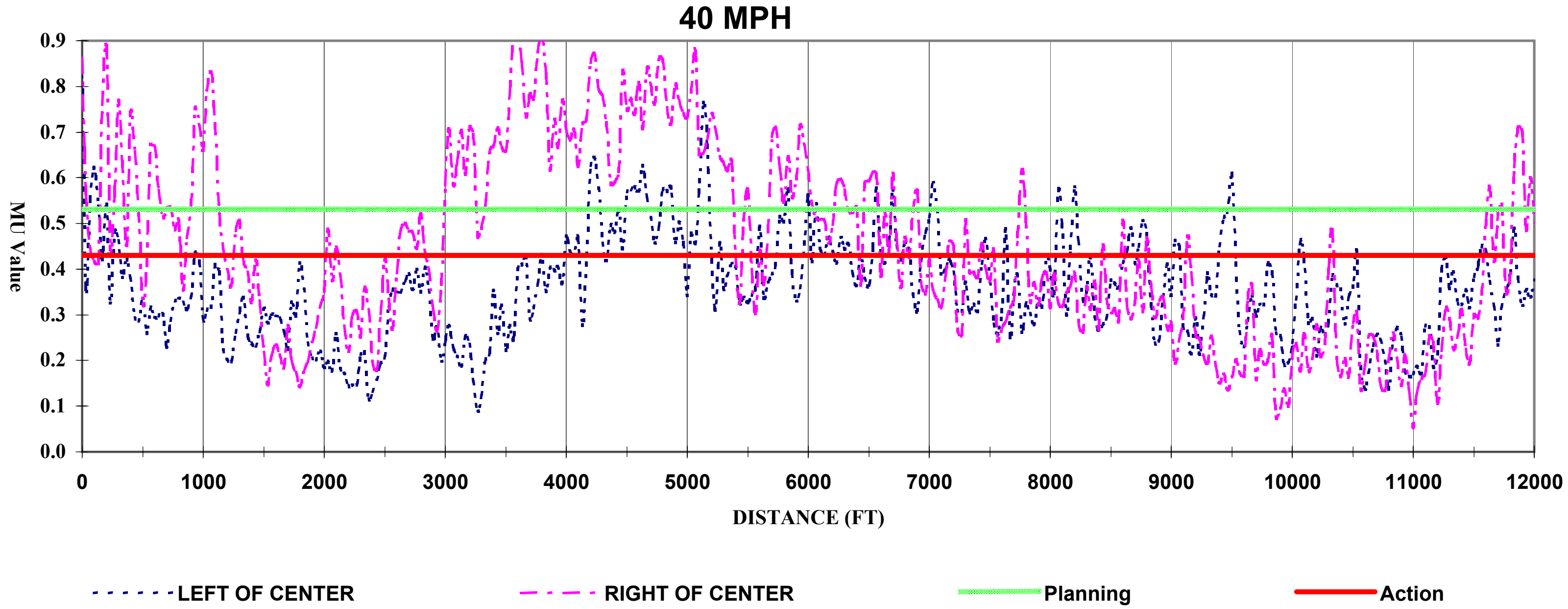
Diego Garcia Runway, BIOT

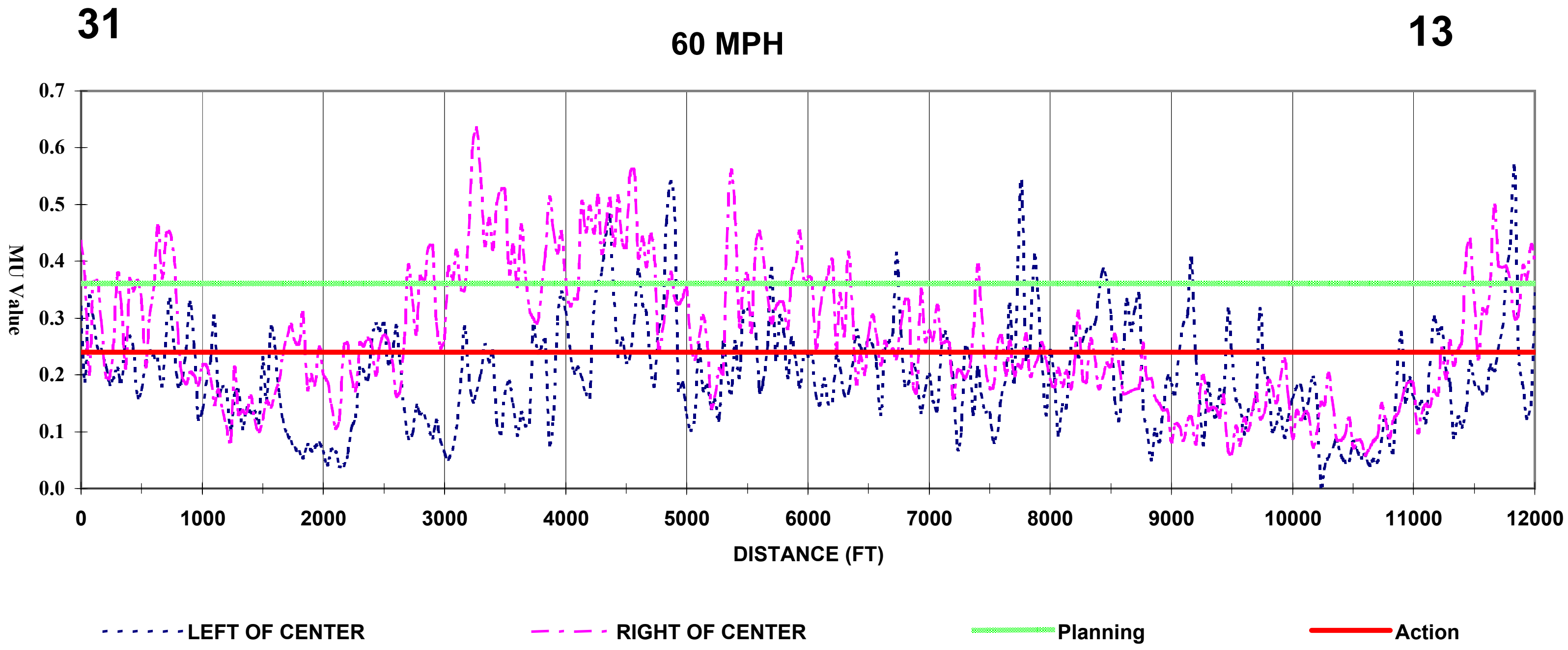
SELF-WETTING GRIP TESTER FRICTION PLOTS



Diego Garcia Runway, BIOT

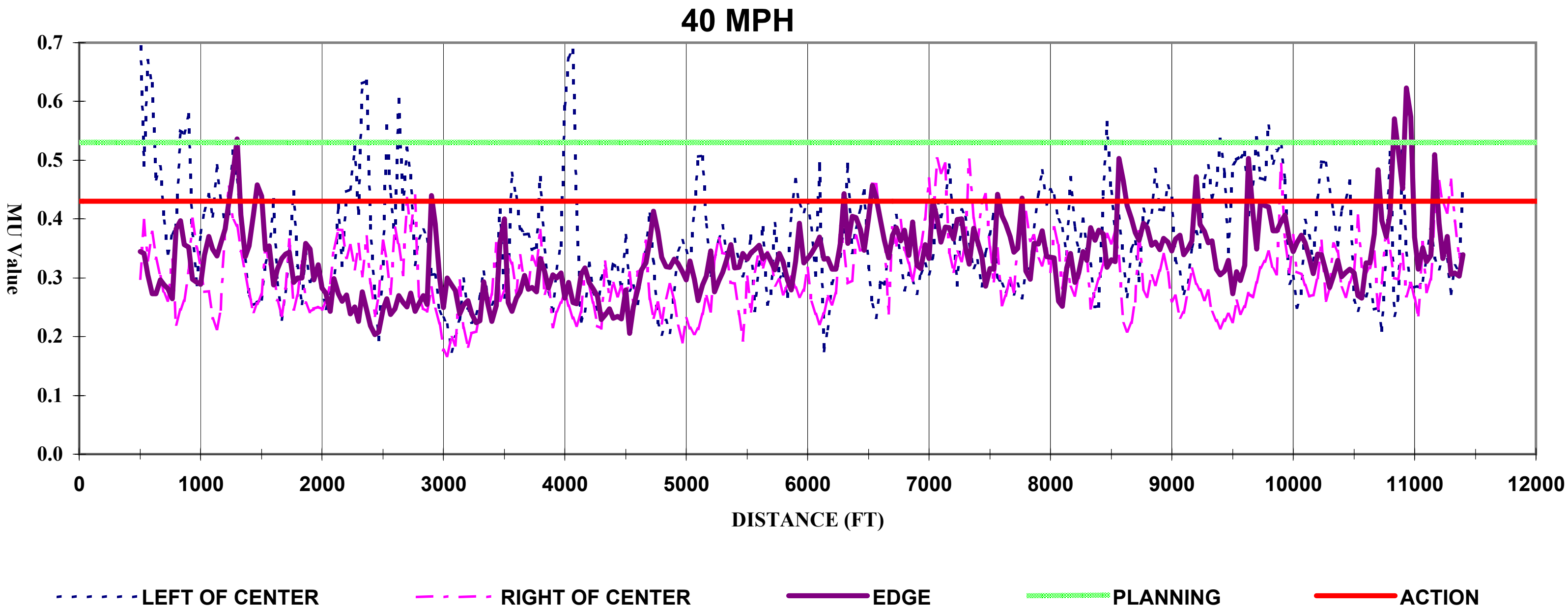
SELF-WETTING GRIP TESTER FRICTION PLOTS





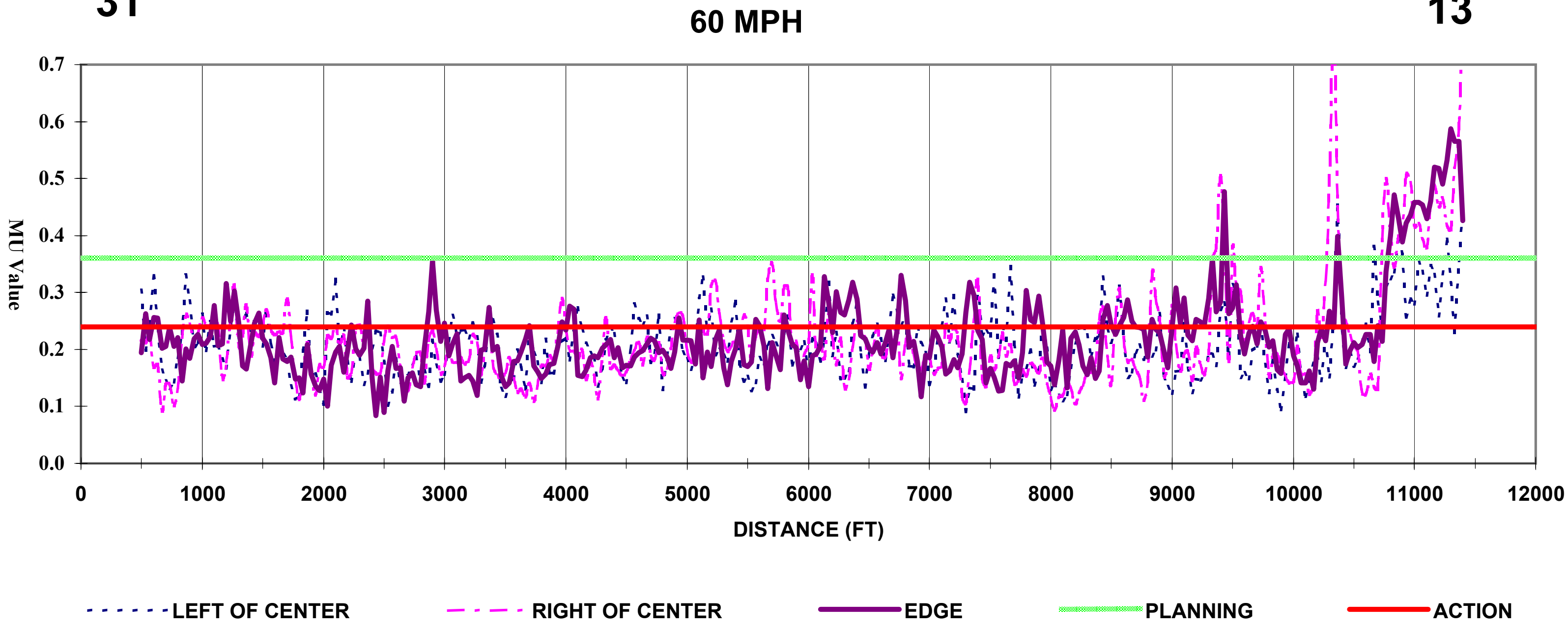
Diego Garcia Taxiway, BIOT

SELF-WETTING GRIP TESTER FRICTION PLOTS



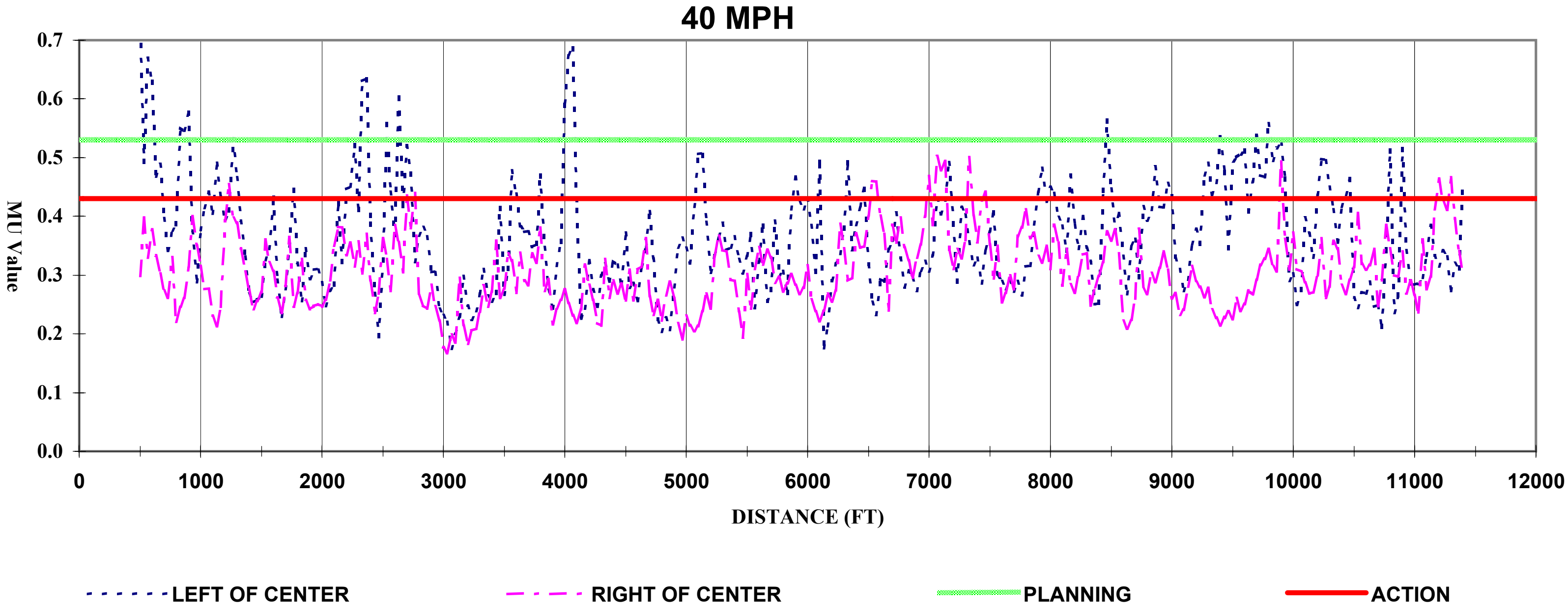
31

13



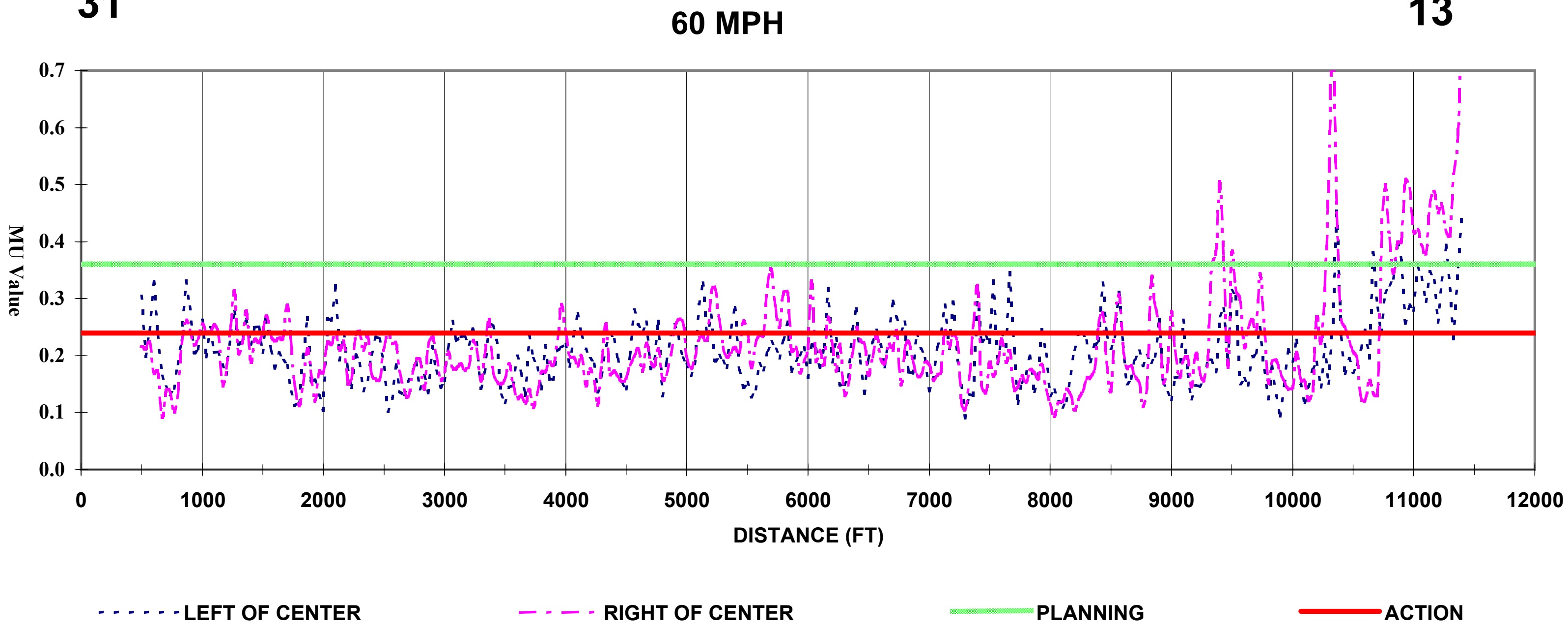
Diego Garcia Taxiway, BIOT

SELF-WETTING GRIP TESTER FRICTION PLOTS


40 MPH

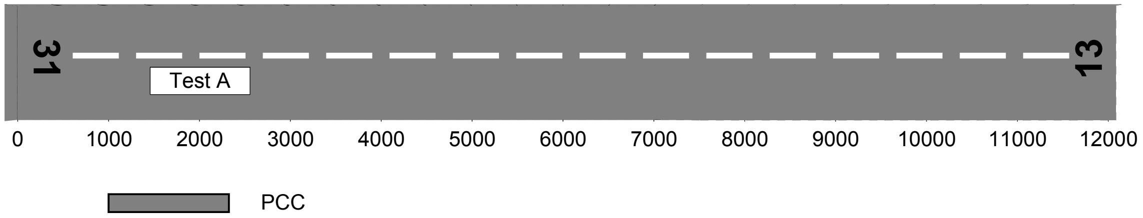
31

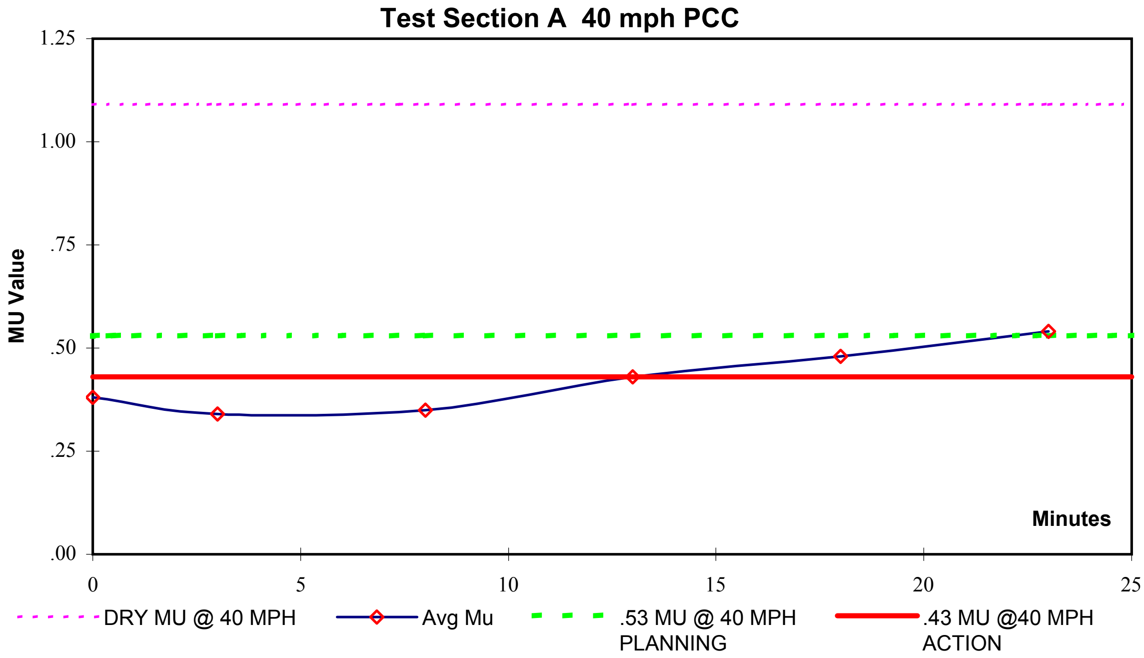
13

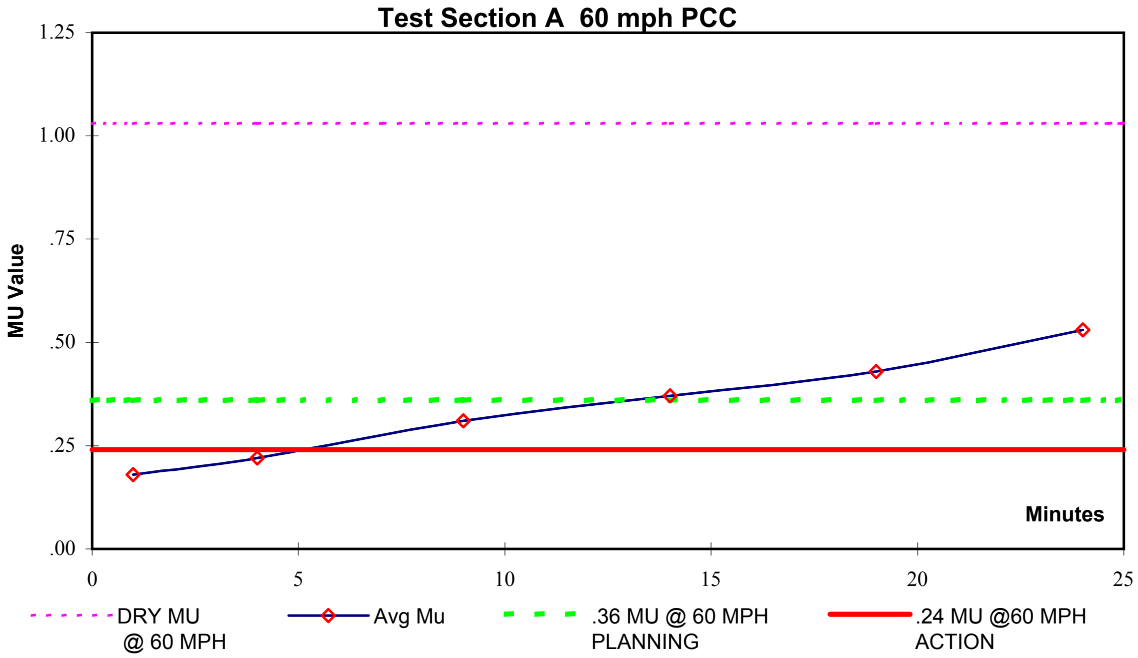

60 MPH

Diego Garcia Runway, BIOT

FLOOD RECOVERY TEST SECTION A

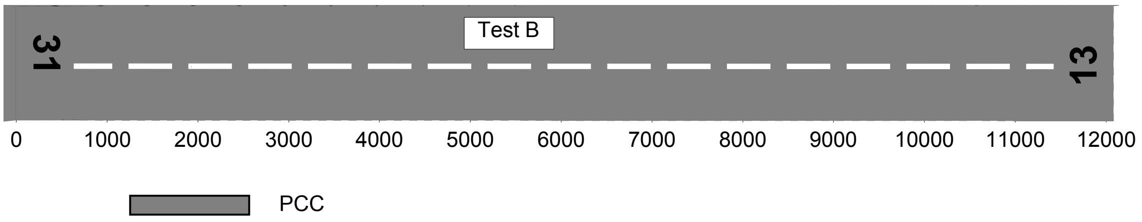




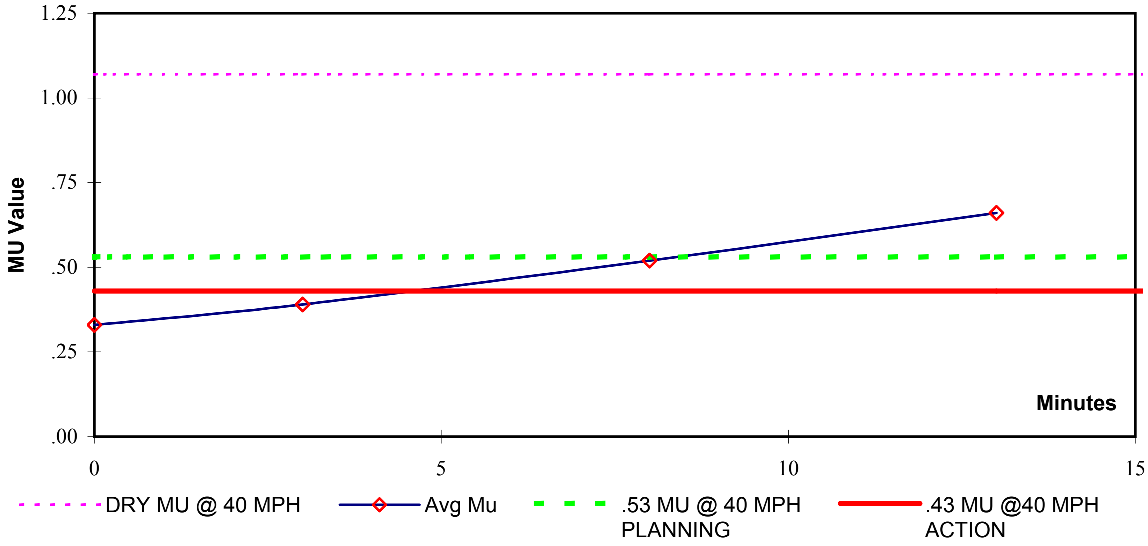


Diego Garcia Runway, BIOT

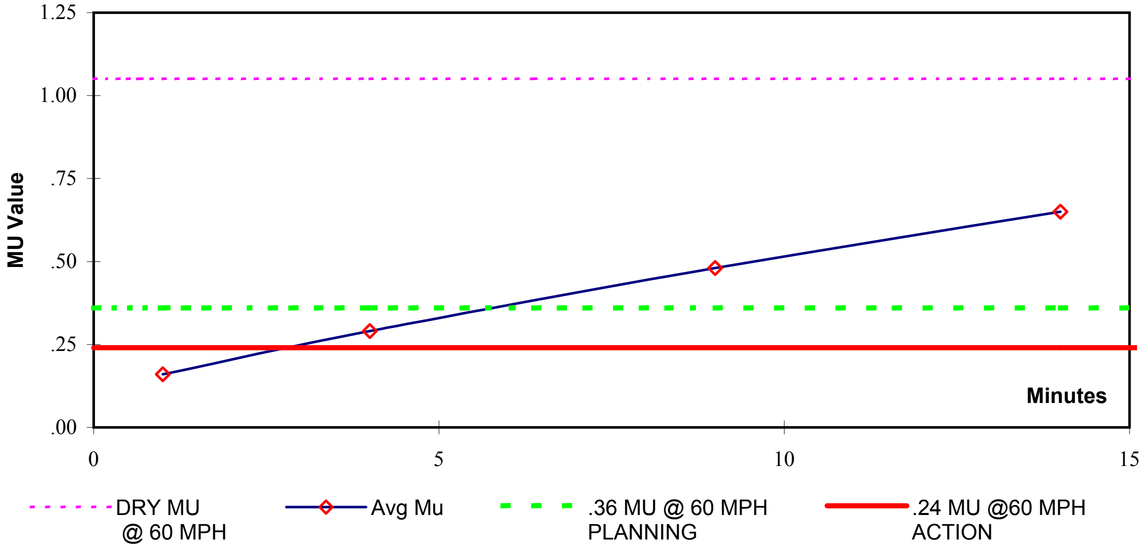
FLOOD RECOVERY TEST SECTION B



Test Section B 40 mph PCC

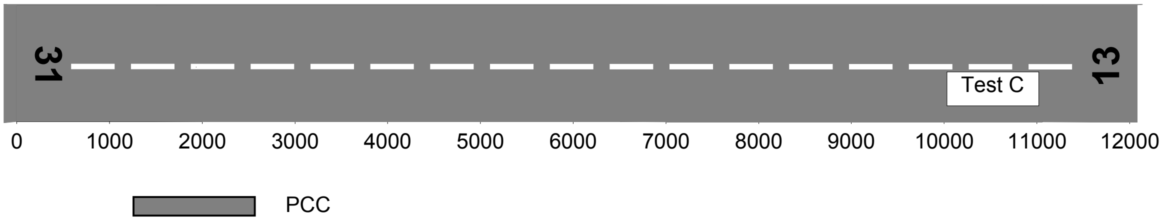


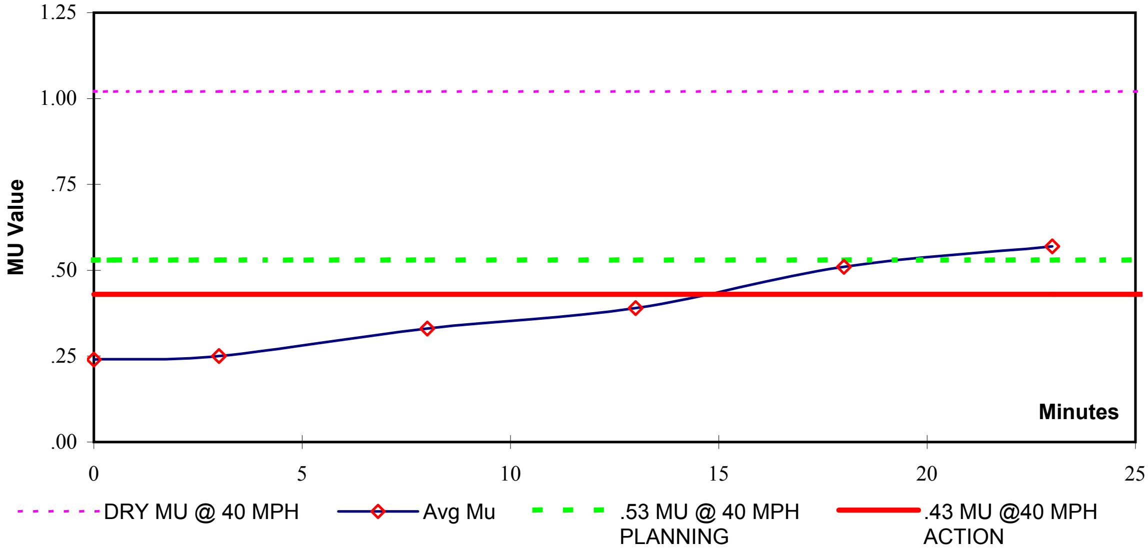
Test Section B 60 mph PCC



Diego Garcia Runway, BIOT

FLOOD RECOVERY TEST SECTION C





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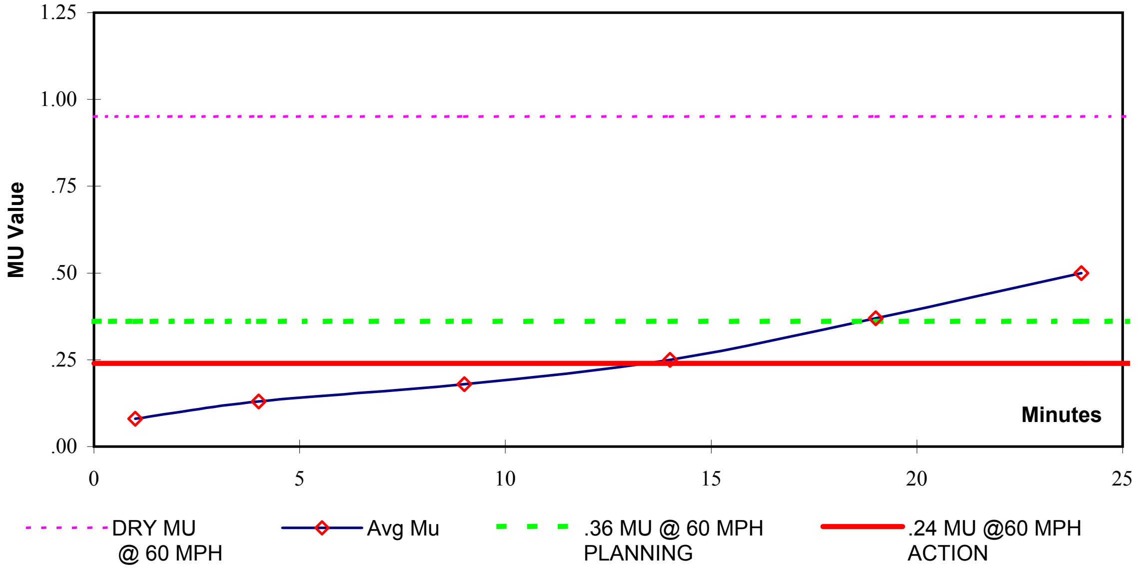
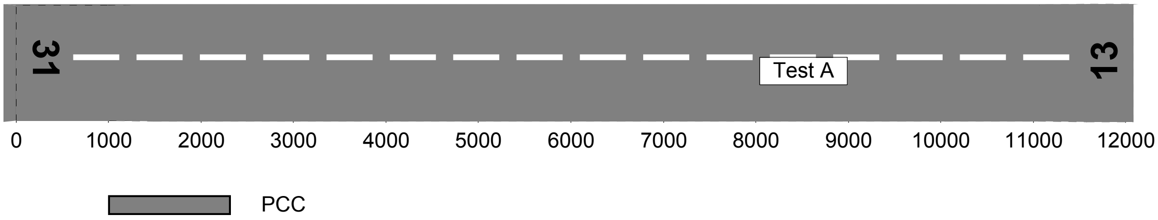
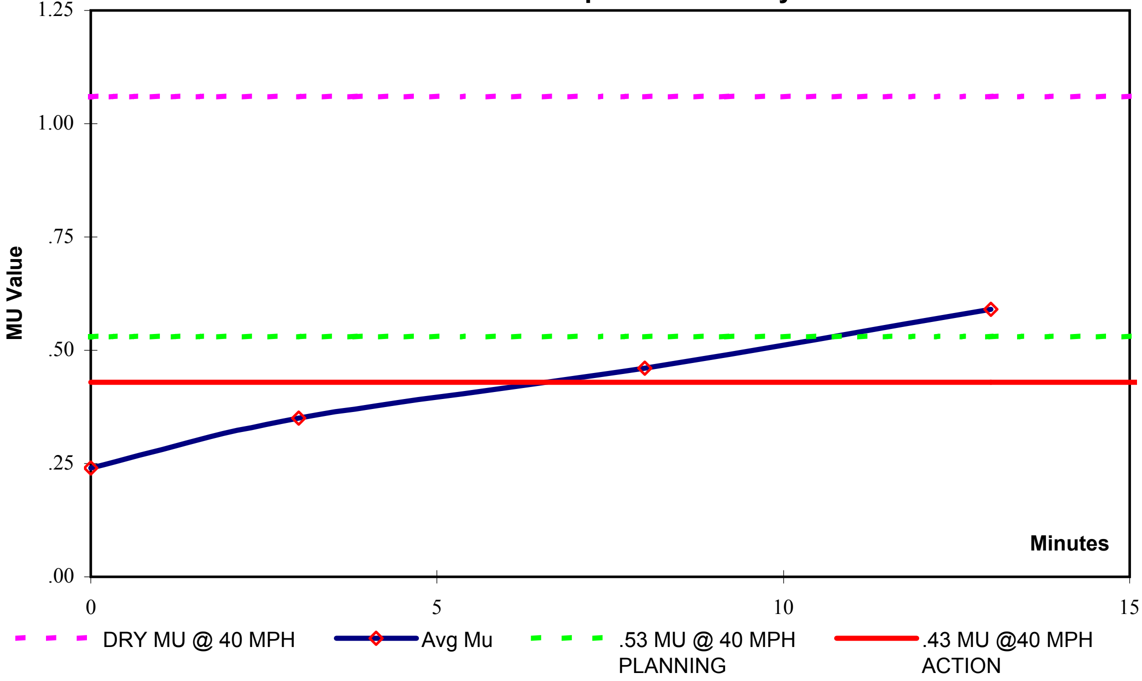


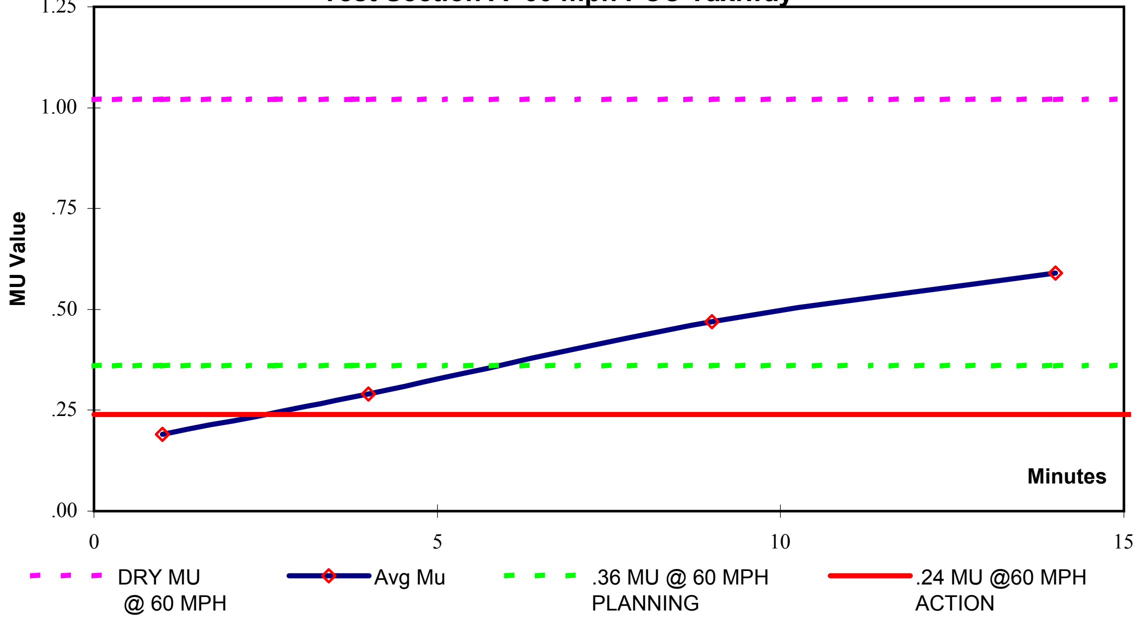
Test Section C 60 mph PCC

Diego Garcia Taxiway, BIOT

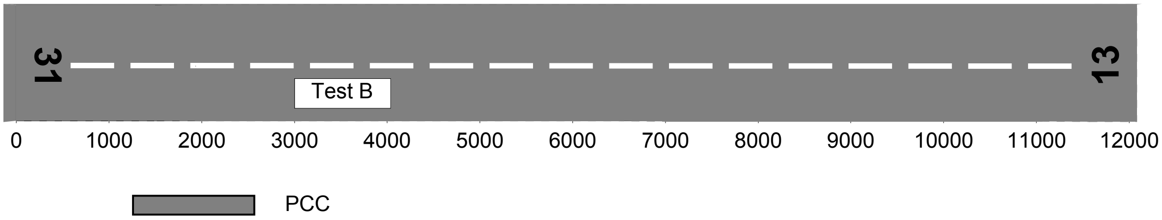
FLOOD RECOVERY TEST SECTION A



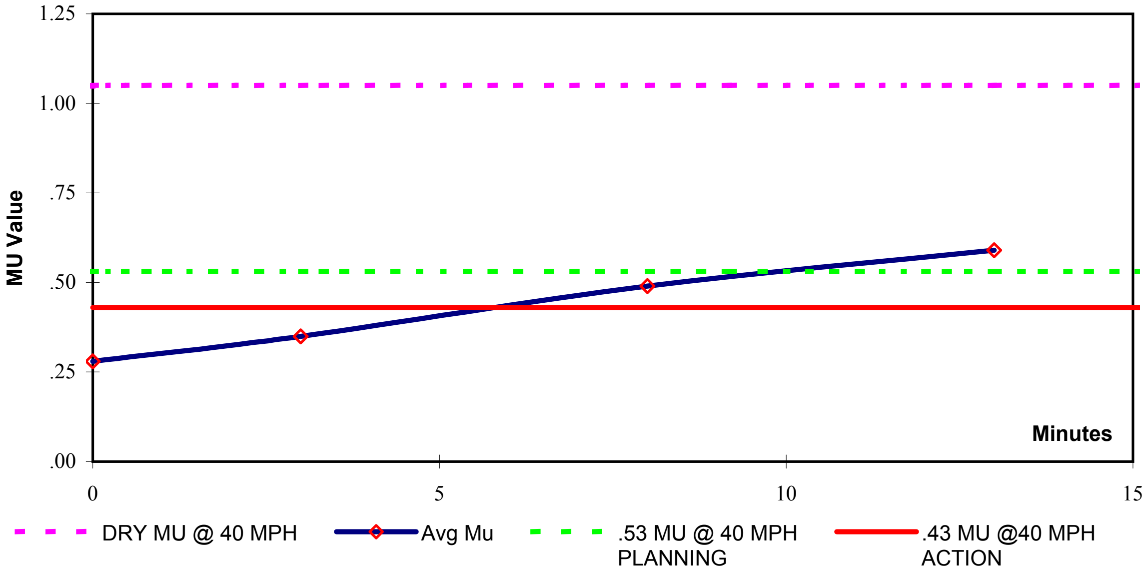

Test Section A 40 mph PCC Taxiway


Test Section A 60 mph PCC Taxiway

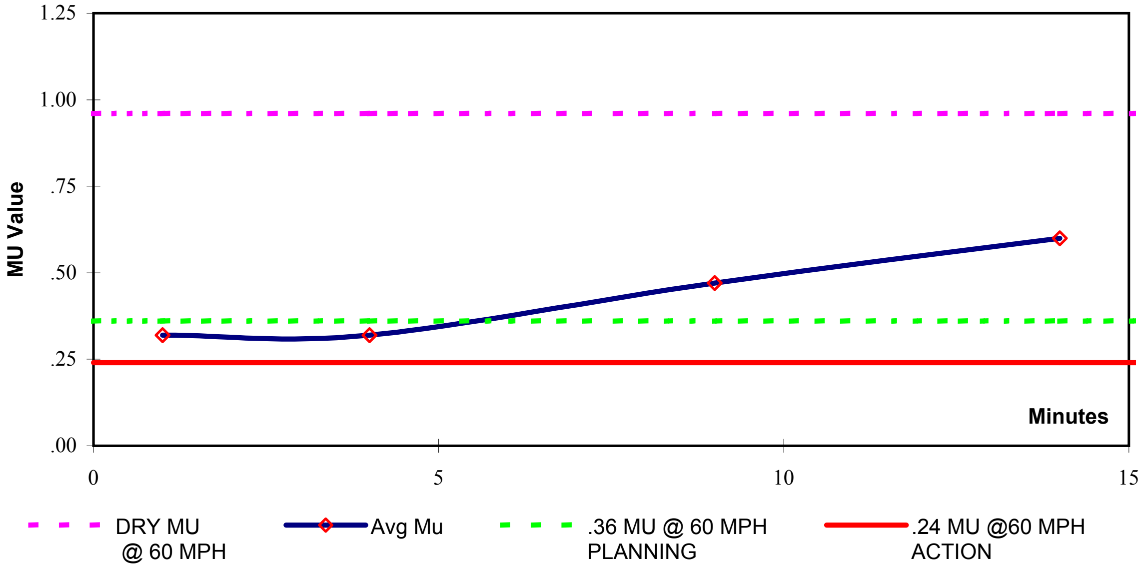
Diego Garcia Taxiway, BIOT
FLOOD RECOVERY TEST SECTION B



Test Section B 40 mph PCC Taxiway



Test Section B 60 mph PCC Taxiway



Estimation of Rubber Deposits

Classification of rubber deposit accumulation	Estimated percentage of rubber covering pavement texture in touchdown zone of runway	Description of rubber covering pavement texture in touchdown zone of runway as observed by evaluator
Very Light	Less than 5%	Intermittent tire tracks; 95% of surface texture exposed.
Light	6 – 20%	Individual tire tracks begin to overlap; 80 – 94% surface texture exposed.
Light to Medium	21 – 40%	Central 6m traffic area covered; 60 – 79% surface texture exposed.
Medium	41 – 60%	Central 12m traffic area covered; 40 – 59% surface texture exposed.
Medium to Heavy	61 – 80%	Central 15-foot traffic area covered; 30 – 69% of rubber vulcanized and bonded to pavement surface; 20 – 39% surface texture exposed.
Heavy	81 – 95%	70 – 95% of rubber vulcanized and bonded to pavement surface; will be difficult to remove; rubber has glossy or sheen look; 5 – 19% surface texture exposed.
Very Heavy	96 – 100%	Rubber completely vulcanized and bonded to surface; will be very difficult to remove; rubber has striations and glossy or sheen look; 0 – 4% surface texture exposed.

Note.- With respect to rubber accumulation, there are other factors to be considered by the airport operator; the type and age of the pavement, annual conditions, time of year, number of wide-body aeroplanes that operate on the runways, and length of runways. Accordingly, the recommended level of action may vary according to conditions encountered at the airport. This table is modified from Airport Services Manual Part 2, Pavement Surface Conditions, Appendix 2, Doc 9137-AN/898.