& Grids & Datums

JAMAICA

BY Clifford J. Mugnier, CP, CMS, FASPRS

The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on Jamaica was originally printed in 2002 but contains updates to their coordinate system since then.

Inhabited by Arawak Indians when Columbus discovered the island in 1494, a Spanish colony was established in 1509. The island was captured by British naval officers William Penn and Robert Venables in 1655, the Spanish being finally expelled in 1658. At that time the total population of the island was estimated at 3,000, chiefly the slaves of the eight hidalgos who were the "lords proprietors," opposed to further European immigration. By then, the native Indian population had been wiped out by the conquistadors, just as the Arawak previously had done to the other peaceful race – the Lucayan of the Bahamas. Of the indigenous population nothing remains but the name of the island, "Xayamaca," the "Land of Springs," and numerous examples of native craft that were left in caves. Jamaica and the Cayman Islands (*PE&RS*, November 1998) were ceded to Britain in 1670 under the Treaty of Madrid and Jamaica remained a British Colony until it became independent in 1962 within the Commonwealth. The island of Jamaica is slightly smaller than Connecticut, and it has a 1,022-km coastline. Jamaica claims a 12-nautical-mile territorial sea, and a continental shelf of 200 nautical miles or to the edge of the continental margin. The terrain is mostly mountainous with a narrow discontinuous coastal plain. The lowest point is the Caribbean Sea and the highest point is Blue Mountain Peak (2,256 meters).

"The island does not lend itself to camping except in the Blue Mountains, so one of the bugbears of the profession is the long walks to and from the field each day. This fact is best illustrated by the experiences of surveyors working in the 'Cockpits,' who have found their days to be each divided into three parts – three hours for the walk to work over trails which have such picturesque names as the 'Devil's Staircase,' leading through the 'District of Look Behind,' six hours behind the instrument and four hours for the return journey to his car or to his lodging" (*Survey Review*, 1955).

The earliest topographic maps of Jamaica were four sheets of Kingston and of Lower St. Andrew at the scale of 2½ inches to the mile made by the Military Authorities in 1909-1912 and known locally as the Pomeroy Map. All other maps were based on compass surveys until the late 1930s.

The Department of Lands and Surveys was formed in 1938, and "the layout of the trigonometrical survey was complete by the end of the year. All lines had been cleared; at the 38 primary stations, 4-foot concrete piers had been built and somewhat smaller piers at 20 secondary stations. At one-third of the primary stations, the observations were completed with the two geodetic Tavistock theodolites in use; they showed triangular closures averaging about 1" (*Tavistock was the name of the town where the manufacturer was located. The instruments were actually made by Cooke, Troughton and Simms – CJM*). All angular observations were made between sunset and midnight to projectors; sixteen pointings on eight zeros exhibited an average range of 4″. It was hoped to com-

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plete the measurement of a 3½ - mile base in Westmorland by January 1939. Invar wires were to be used. An azimuth was observed in Trelawny, with a probable error of about ± 1″. The fixing of latitude, longitude and check azimuths had not been undertaken at the date of reporting." "The azimuth observations were made at Maxwell Hall hill, Kempshot (*sic*) on the 28th and 30th of March, 1938. Using *Ursa Minor* at or near elongation the azimuth of the side Maxwell Hall-Etingdon was determined. In all, thirty-two pointings were made, and the probable error of the result is 1″. The azimuth of the side was calculated (and later corrected) to be $\alpha_0 = 81^\circ\ 16'\ 36.25''$."

"*Datum Latitude and Longitude:* — In accordance with the original instructions from the Geographical Section (*of*) the General Staff, the Flagstaff in Fort Charles, Port Royal, the latitude and longitude of which had previously been determined to be $\Phi_0 = 17^\circ\ 55'\ 55.8''$ N, $\Lambda_0 = 76^\circ\ 50'\ 37.26''$ West of Greenwich, was taken as the triangulation origin. It has been connected to the triangulation by intersections from: Wareika, Montpelier, Red Hills, Rodney's Lookout, Plumb Point."

"*Datum Level:* — A line of level (*sic*) was run from the Plumb Point station to the Admiralty Datum in the swimming bath at Port Royal. The mark is reported to be … 3.50 ft. above mean sea level. The distance from Plumb Point to the Port royal bath is 4½ miles and the disagreement between the outward and return leveling was .086 of a foot, a very good result obtained by Sergeant D.K. Black, R.E. (*I. J. Harris, Capt., R.E., 20th May, 1939*)." Note that ordinary differential leveling would allow a total error of ± 0.106 feet even by 21st Century standards. The Clarke 1880 ellipsoid was referenced (and modified for Jamaica) such that a = 6,378,249.136 m and $^1/_f$ = 293.46631. The Lambert Conical Orthomorphic was chosen as the projection for Jamaica, and quite interestingly was designed to be a tangent conic where $m_0 = 1.0$. Using feet as the unit of measure until 1980, the defining parameters of the "Jamaica Foot Grid" are central meridian, $\lambda_0 = 77^\circ$ W, latitude of origin, $\varphi_0 = 18^\circ$ N, False Easting = 550,000 feet, and False Northing at the latitude of origin = 400,000 feet, all on the Fort Charles Flagstaff Datum of 1938. The first complete coverage of the island with aerial photography was flown in 1941-1942. The British Directorate of Overseas Surveys (DOS) compiled 12 topographic maps of the island at 1:50,000 scale in 1947, and this was the first DOS project undertaken by the new agency. Brigadier Martine Hotine (the father of the Rectified Skew Orthomorphic Oblique Mercator projection) was the *only* Director of the DOS for its entire existence. Of course, the units were feet for this edition, even though the scale was metric.

In April of 1969, Keith A. Lee wrote: "In the original scheme only one azimuth had been observed by the Royal Engineers; that line Maxwell Hall to Etingdon being situated near the western end of the island. It was considered prudent to determine the azimuth of another line and preferably one in the eastern part of the island. For reasons of accessibility and convenience the line Coopers Hill to Nutfield was chosen. On the night 24/25 October, 1968, the azimuth of this line was deter-

mined by observations on Polaris. The instrument used was Wild T3 No. 53112 and the observations were made on the 16 circle positions recommended in "The Retriangulation of Great Britain." Not having the equipment for a proper determination of astronomical coordinates, the listed geodetic position of the stations was used in computing the azimuth. It was noted that this computed azimuth was 10.01″ larger than the listed geodetic azimuth of the Royal Engineers'. The observation was thought to be of a fairly high standard – the *p.e.* being ± 0.29″ – and although a systematic swing was present in the individual determinations it was certainly not of the order of 10″." Further investigations by Lee proved that the original reference azimuth of the old Fort Charles Flagstaff Datum of 1938 was in error as a combination of mathematical blunder and probably deflection of the vertical. Note that the reference azimuth quoted with the definition of the old datum was the corrected value that was carried in the readjustment discussed in the following paragraphs. Lee did recommend that the original origin point for the datum be retained, and it was.

From Watson almost 40 years after Captain Harris: "In 1969 it was decided to readjust the primary triangulation of Jamaica and to incorporate into the new adjustment all additional and relevant observations made since the previous adjustment. In particular, many electronic distance measurements and some additional astronomical azimuth information were now to be included. At the same time it was decided to change spheroids and carry out all computations on the Clarke 1866 spheroid instead of the current Clarke 1880 spheroid! These decisions were agreed between the Jamaica Survey Department and the Directorate of Overseas Surveys. Although quite unusual when readjusting a datum to go to an older ellipsoid of reference, in this case the reason was that the Inter-American Geodetic Survey had extended the North American Datum of 1927 into the Caribbean. In the case of Hong Kong (*PE&RS*, January 1998), the ellipsoid was changed to an older one to allow for a 'better fit' for a readjustment.

The bulk of the triangulation was observed and adjusted by a team of Royal Engineers during the period 1937-45. Finally, during 1951-62 a team of surveyors from the Directorate of Overseas Surveys (DOS), assisted by members from the local department, measured by Tellurometer a good selection for the primary lines" (*Tellurometer was a brand name of electronic distance meter once manufactured in South Africa. – CJM*).

"The local department would undertake the daunting task of producing abstracts and/or Photostat copies of all observed angles and lengths held by them. These abstracts together with the observed angles and lengths held by DOS would constitute the data for the new adjustment. Historically, this task involved using angles observed between 1937 and 1970 by the local department on different types of survey using different types of instruments. In addition, from 1960 onwards, length measurements by Tellurometer and other electronic distance measuring equipment were carried out by both DOS and the local department. DOS observed Tellurometer traverses all around the island between primary stations and produced a network of Tellurometer traverses in the Cockpit part of the country. The local department extended and strengthened existing minor work all over the island by triangulation and Tellurometer traverse.

During the next few years, the local department prepared and sent batches of data and annotated diagrams on map sheets. In 1971-72, after consultation with the local department and DOS, a detachment of Royal Engineers, under the code name "Calypso Hop," observed additional angles and lengths in some of the weaker points of the framework. Finally in 1974, a start was made on the secondary and minor adjustment by producing fresh diagrams showing all the information supplied by the local department and held by DOS. Missing data, as revealed by the diagram, and obvious errors which arose during the plotting of the data, were referred back to Jamaica, which department continued to send further information as their diligent searches of their records brought them to light. Close and friendly cooperation with the local department helped considerably with this huge task of collating and collecting the data.

Naturally the moment had to come when a halt had to be called to any further additions to the data to be adjusted. Any weaknesses in the framework would be revealed in the results of the adjustment, and these weaknesses could be strengthened in the future, though, here, it must be added that serious consideration should be given to trying to hold adjusted coordinates for say 20 to 30 years before attempting a complete readjustment. Too much localized chopping and changing leads to confusion and a lack of continuity. This may appear to be a rather pragmatic approach but surveyors and engineers are pragmatic people and surveys have still to be started and computed from the best results available at the time.

It must be remembered that no coordinates are ever final, and, if certain small areas of the adjustment are weaker than the mainly strong whole, additional field work can be carried out in the future to strengthen those weaker areas and if absolutely necessary, small controlled readjustments carried out. Following on from the adjustments, some 291 offset points were fixed by azimuth and Tellurometer length and, finally, 36 additional points were computed mainly by the method of intersection. Geographical coordinates and Lambert Conical Orthomorphic projection coordinates were computed for 1,392 points" (*W. Watson, April 1977*).

The Jamaica Datum of 1969 retained the original origin point at the Fort Charles Flagstaff where $\Phi_o = 17^o\ 55'\ 55.8''$ N and $\Lambda_o = 76^o\ 50'\ 37.26''$W, the reference azimuth $\alpha_o = 81^o\ 16'\ 36.25''$, was used as corrected by Lee, and the ellipsoid of reference was now the Clarke 1866 where: a = 6,378,206.4 m and b = 6,356,583.6 m. The new unit of measure was the meter, the redefined "Jamaica Metre Grid" retained the original parameters except for the change in ellipsoid, the False Easting was now 250 km, and the False Northing at the latitude of origin was now 150 km. Deflection of the vertical at the flagstaff was equated to zero, as was the geoid-ellipsoid separation. However, the new grid did not appear on official topographic maps until 1981.

Control densification work continued by the Jamaica Survey Department, and DOS with its library was incorporated

into the Ordnance Survey of Great Britain. A combined adjustment of the original 1969 DOS data along with the control densification and trigonometric levels was performed in 1984 with excellent results. Minor problems with the original 1969 adjustment were corrected, and the final adjustment was performed in blocks with a PDP 11/34 mini computer (that's the same model of computer many of us old Photogrammetrists used to have that powered our analytical stereoplotters).

On 16 November 1994, the Government of Jamaica signed a formal treaty with the Government of the Republic of Cuba on the delimitation of the maritime boundary between the two states. Based on the mutually agreed principle of the equidistance method, a list of 106 points was filed with the Secretary General of the United Nations. Although the points were plotted on navigation charts, it was explicitly noted in the treaty that the charts were intended for illustrative purposes only, and the lines connecting the tabulated points were defined as geodesics on the North American Datum of 1927 and the Clarke 1988 ellipsoid (a geodesic in this case is defined as the shortest distance on the surface of the ellipsoid of revolution).

Jamaica filed a formal declaration with the Secretary General of the United Nations under the United Nations Convention on the Law of the Sea regarding its claim to territorial waters based on Jamaica's archipelagic basepoints as of 14 October 1996. The list of coordinates is comprised of 28 points described in latitude and longitude to the closest integer arc second "referenced to the North American Datum of 1927 (NAD27) and based on Clarke's (1866) spheroid with a semimajor axis of 6,378,206.4 metres and a flattening of 1/294.978." Since the text of the declaration includes reference to those basepoints plotted on navigation charts, the projection is a normal Mercator and therefore the "straight lines" connecting the basepoints are ellipsoidal loxodromes or rhumb lines. Readers may recall that it was Snellius, the father of geodesy that coined the word "loxodrome" (*PE&RS*, February 2003).

NIMA lists the transformation parameters for Jamaica from the NAD27 to WGS84 as a mean of 15 stations observed throughout the northern portion of the Caribbean as: $\Delta a = -69.4$, $\Delta f \times 10^4 = -0.37264639$, $\Delta X = -3$ m ± 3 m, $\Delta Y = +142$ m ± 9 m, and $\Delta Z = +183$ m ± 12 m. In addition, in 1996 the U.S. National Geodetic Survey (NGS) observed several existing triangulation stations at the Norman Manley International Airport in Kingston, Jamaica. Dave Doyle of the NGS graciously provided the local coordinates of a number of points at the airport. In particular for "Airport 5," $\varphi = 17^\circ\ 56'\ 06.776''$ N, $\lambda = 76^\circ\ 47'\ 44.836''$ W, Northing = 142,844,681 m, Easting = 271,626.526 m, and the observed NAD83 geodetic coordinates are $\varphi = 17^\circ\ 56'\ 16.27529''$ N and $\lambda = 76^\circ\ 47'\ 41.29986''$ W. Computing the three parameter geocentric transformation from JAD69 to NAD83 for this single point yields $\Delta X = +58$ m, $\Delta Y = +209$ m, and $\Delta Z = +392$ m. The large differences with NIMA mean values, however, have a simple explanation. NIMA values for Jamaica are for the transformation from NAD27 to WGS84; they are not from JAD69 to WGS84. Although both classical datums are referenced to the Clarke 1866 ellipsoid, note that the origin coordinates for JAD69 are exactly the same as for the Jamaica Datum of 1938: it's at the Fort Charles Flagstaff! The reader will recall that the origin for NAD27 is at Meades Ranch in Kansas, and that is quite a long distance from Jamaica.

Prof. Glendon G. Newsome of the University of Technology in Kingston and Prof. Bruce R. Harvey of the University of New South Wales wrote a paper on transformations in Jamaica and they used four fiducial points on the island. The three parameters from JAD69 to WGS84 they solved for are $\Delta X = +65.33$ m ± 0.96 m, $\Delta Y = +212.46$ m ±1.49 m, and $\Delta Z = +387.63$ m ± 0.69 m. Newsome and Harvey acknowledge the critical need for a good geoid for Jamaica, and they hope for the day when a new national datum may be established. Thanks also go to Prof. Hugart Brown, retired from the Metro State College of Denver, for his kind help over the years with Jamaican survey history. Thanks to Russell Fox of the Ordnance Survey of the United Kingdom and his soon to be closed International Library for all of his help.

Jamaica Update

In 2008, the Ministry of Agriculture established a GPS RTK Virtual Reference System for the island consisting of a five-station network.

http://www.spatialvision.com/ministry-of-agriculture-jamaica-signs-major-contract-with-spatial-innovision-to-deliver-the-national-gps-infrastructure/

In 2012, The Jamaica VRS and Cadastral Surveying was discussed by Prof. G. G. Newsome, Prof. G. Peake, and Mr. R. Douglas in the September issue of Coordinates magazine.

https://mycoordinates.org/the-jamaica-vrs-and-cadastral-surveying-2/

In 2015, The Spatial Active Global Geomatrix was presented by Mr. Siburn Clark, RICS and Mr. Douglas Nelson at the 4th Annual Caribbean Valuation & Construction Conference in which they discussed the 13 CORS sites in Jamaica of the VRS system.

file:///Users/cliff/Downloads/ClarkeNelson2015SpatialActiveGeomatrixRICSIPTICaribbeanValuationConstructionConference.pdf.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for GeoInformatics (C^4G).

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