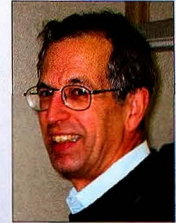


## Surveying a Land Boundary Reference Point Used in the Guyana-Suriname Maritime Boundary Delimitation

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### Abstract

The delimitation of the maritime boundary between Guyana and Suriname by a tribunal constituted in accordance with the UN Convention on the Law of the Sea and acting under the auspices of the Permanent Court of Arbitration required the tribunal to consider the precise geographic location of a marker established in 1936. That marker would become a reference point for the first segment of the maritime boundary. This necessitated a visit to the site of the marker by the Tribunal's Hydrographer. This paper outlines the efforts and the precautions taken during that site visit.



### Résumé

La détermination des limites maritimes entre le Guyana et le Suriname par un tribunal constitué conformément à la Convention des NU sur le Droit de la mer et agissant sous les auspices de la Cour permanente d'arbitrage, a nécessité que le tribunal examine la localisation géographique précise d'une balise mise en place en 1936. Cette balise deviendra donc un point de référence pour le premier segment de la frontière maritime. Pour cela, l'hydrographe expert près le Tribunal a dû se rendre sur le site de la balise. Cet article souligne les efforts fournis et les précautions prises au cours de la visite de ce site.



### Resumen

La delimitación de la frontera marítima entre Guyana y Suriname por un tribunal constituido según la Convención de las NN.UU. sobre la Ley del Mar y que actúa bajo los auspicios de la Corte Permanente de Arbitraje requirió que el tribunal considerase el emplazamiento geográfico preciso de una marca establecida en 1936. Esa marca se convertiría en un punto de referencia para el primer segmento de la frontera marítima. Esto requirió una visita del Hidrógrafo designado por el Tribunal al lugar donde se encontraba la marca. Este artículo destaca los esfuerzos y las precauciones tomadas durante esa visita a dicho lugar.

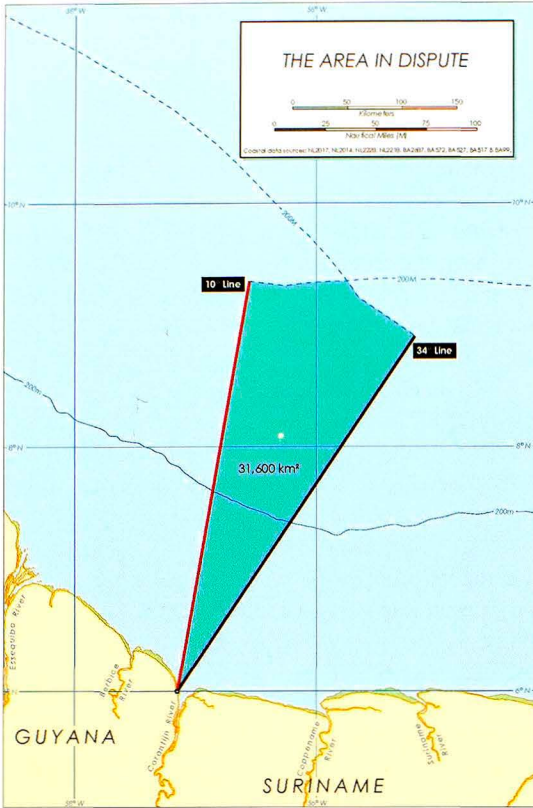


Figure 1: The claims made by Guyana and Suriname for the maritime boundary. [Source: Map 1 of Guyana-Suriname Award.]

In November 2006, the author was appointed the “Hydrographer” assigned to assist the Arbitral Tribunal constituted to determine the maritime boundary between Guyana and Suriname. The scope of the work was outlined to him in the Hydrographer’s Terms of Reference:

- 3.1 The Expert shall assist the Arbitral Tribunal, should it determine that it has jurisdiction to do so, in the drawing and explanation of the maritime boundary line or lines in a technically precise manner.
- 3.2 The Expert will make himself available to assist the Arbitral Tribunal as required by it in the preparation of the Award.
- 3.3 The Expert shall perform his duties according to international hydrographic and geodetic standards.

What are the international standards for hydrography and geodesy that he was to abide by? To complicate matters, the Guyana-Suriname arbitration had a new

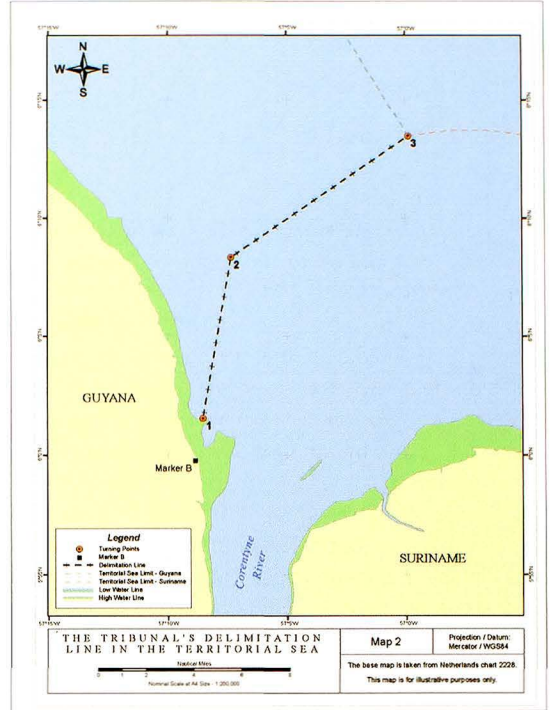


Figure 2: The maritime delimitation between Guyana and Suriname within their territorial seas as awarded by the Tribunal. [Source: Map 2 of Guyana-Suriname Award.]

dimension that has not arisen in previous arbitrations; namely, a requirement to perform a site visit. What standards are required for a site survey?

**How the Site Visit Became Required**

Guyana claimed that the maritime boundary ought to extend from a point on the Low Water Line that was nearest to a reference point, Marker “A”, established in 1936 to the 200 nautical limit of its Exclusive Economic Zone along a rhumb line of N34°E. Suriname, on the other hand, claimed that the Tribunal did not have jurisdiction to arbitrate the case, and if it did, then the maritime boundary delimitation ought to extend from the Low Water Line to the 200 nautical mile limit of its Exclusive Economic Zone along the rhumb line of N10°E which passes through Marker “A”. See Figure 1. Thus, the geographic location of Marker “A” was significant to the delimitation of the maritime boundary close to shore.

The site visit was not conceived from the outset of the arbitration. In fact, Guyana was the first to suggest such a visit during the Oral Hearings. The even-

tual necessity for a site visit was determined mainly for technical reasons.

### Information acquired form Pleadings

In 1799, the border between Suriname and Berbice, now the eastern part of Guyana, was agreed by colonial authorities to run along the west bank of the Corentyne River. A Mixed Boundary Commission was formed in 1934 to establish the southern and northern points of the boundary with greater precision. In 1936, the Commission recommended a specific point on the west bank of the Corentyne River, near to the mouth of the river as the northern terminus; this point was to be located by reference to a marker placed at a point referred to as "Point 61" by Guyana in its pleadings and as "1936 Point" by Suriname in its pleadings. The rationale for locating the border along the western bank of the Corentyne River and locating the land boundary terminus on the western bank was to enable The Netherlands to exercise supervision of all traffic in the river." The Mixed Boundary Commission established a buried concrete monument inscribed with an "A" on its upper surface at the location mentioned above, and a visible concrete pillar 3 metres away. The Commission also concluded that the maritime boundary in the territorial sea should be fixed at an azimuth

of N10°E from the point where the line drawn on a N10°E azimuth from Point 61/1936 Point intersected the low water line to the limit of the territorial sea." It then established a similar buried concrete monument inscribed with a "B" on its upper surface 220 metres on an azimuth of 190° from Marker "A". This buried marker was also referenced by a visible concrete pillar 3 metres away. The two pillars were placed on the extensions of the line joining Marker "A" and "B". Additionally, there was a 10-metre high triangular beacon built 30 metres from Marker "B" along the extension of the line through "A" and "B" in 1938 as part of the 1936 boundary survey and it is still [2007] shown on both the British and Dutch charts, although the beacon ceased to exist prior to 2004." See Figure 3 for a sketch of the layout of the monumentation.

The report prepared by the Mixed Boundary Commission provides the astronomic position of Marker "A" as

Latitude 5° 59' 53.8"N,  
Longitude 57° 08' 51.5"W

and of an astronomic pier just North of Rest House 63 at

Latitude 5° 59' 00.09"N,  
Longitude 57° 08' 55.12"W.

The document filed with the Tribunal is indistinct in its latitude value.

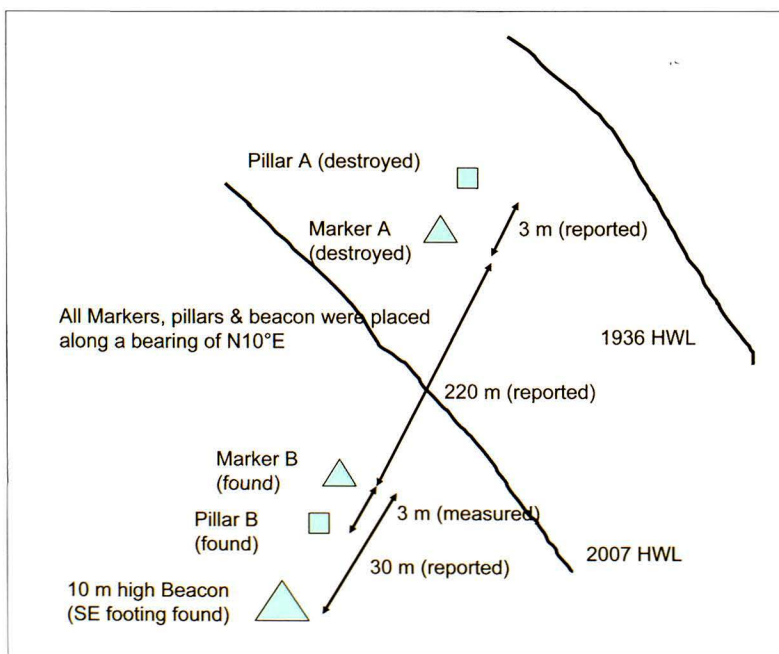


Figure 3: sketch of the layout of the monumentation.

In 1960, the Inter-American Geodetic Survey reported that Marker "A" was in the inter-tidal zone and had been disturbed by the action of the sea. The nearby pillar had been destroyed by the action of the sea. Therefore the Geodetic Survey connected Marker "B" to its Tellurometer traverse instead. The surveyed position was not provided in the documents filed with the Tribunal.

In preparation for writing its pleadings, Guyana sent its hydrographer and some of its lawyers to the site. They found Marker "B" and its associated pillar, but they

claimed that the location of Marker "A" was in the inter-tidal zone and that there was no indication of its existence. They determined World Geodetic System 1984 (WGS-84) of Marker "B" from which Guyana calculated the position of Marker "A" as:

Latitude 6° 00' 05"N,  
Longitude 57° 08' 44.5"W.

The Beacon was still, in 2007, shown on British Admiralty chart 99 at:

Latitude 5° 59' 43"N,  
Longitude 57° 08' 51.5"W

and on Dutch chart 2228 at:

Latitude 5° 59' 56"N,  
Longitude 57° 08' 43.5"W.

The above data were all known by the time the Tribunal's Hydrographer convened a preliminary meeting of the parties' technical experts during the oral hearings. The Hydrographer was attempting to find some common ground on several technical points and extra technical information, and asked the technical experts to provide:

- a) the relationship of the geographic grid of the relevant British Admiralty, Dutch and American charts to WGS-84,
- b) the position of Marker "B", and other points in the 1960 survey within the geographic area of the mouth of the Corentyne River, their geodetic datum, and the WGS-84 datum position of these points if they have been determined by re-computation of the 1960 survey.

At the time of the meeting, it was unclear whether Marker "A" might be, in some way, connected to the starting point of the maritime boundary, but if it were, its WGS-84 position would be required. Would Suriname accept the WGS-84 position of Marker "B" filed by Guyana? Could the WGS-84 position be derived from the astronomic position? Could the WGS-84 position be derived from the charted position of the beacon? Could the WGS-84 position be derived from the 1960 surveyed position of Marker "B"? Was there agreement amongst these various approaches to the position determination?

## Results of Requests

The geodetic datum shift for Dutch chart 2228, and other specified charts, was provided by Suriname in terms of the 7 parameters required for a Molodensky transformation. That being said, the three rotations

about the axes were zero and there was no scale change; so it really boiled down to the 3-parameter Molodensky transformation. These values were consistent with the 3 parameters ( $\Delta X$ ,  $\Delta Y$ ,  $\Delta Z$ ) listed in the International Hydrographic Organization's Handbook on Geodetic Datums but for Venezuela rather than for either Guyana or Suriname, which were slightly different. It was assumed that the appropriate ellipsoid would be the same ellipsoid used in the 1956 Provisional South American [geodetic] Datum because that ellipsoid was used in the Handbook on Geodetic Datums to compute the datum shifts for Venezuela, Guyana and Suriname. The datum assumption was later confirmed by Suriname. Applying this transformation to the charted position of the Beacon and then applying the azimuth and distance to Marker "B", the resulting WGS-84 position is:

Latitude 5° 59' 45.88"N  
Longitude 57° 08' 48.83"W.

The Handbook on Geodetic Datums provides estimates of the accuracy of the shifts in the Cartesian coordinates as  $\pm 9$  metres in X,  $\pm 14$  metres in Y, and  $\pm 15$  metres in Z. The three-dimensional accuracy is the square root of the sum of the squares of these values, or  $\pm 22.4$  metres, which is roughly 0.7 seconds of arc in latitude or longitude.

British Admiralty chart 99 of the Corentyne River was not included in Suriname's response and its geographic relationship to WGS-84 was considered to be unknown. However the chart identifies the geographic relationship to the Dutch chart 2228 as 15 seconds northward and 9 seconds eastward, approximately.

Neither party was able to provide any information concerning the 1960 Inter-American Geodetic Survey Tellurometer traverse.

The Mixed Boundary Commission's 1936 report gives the astronomic position of Marker "A", from which one can compute the astronomic position of Marker "B" as:

Latitude 5° 59' 46.747"N  
Longitude 57° 08' 54.542"W.

There is no indication in the Commission's report as to the method of observation for latitude and longitude. That astronomic position can be converted into a WGS-84 position by applying the deflection of the vertical corrections in latitude and longitude, which resulted in a WGS-84 position of:

Latitude 5° 59' 43.45"N  
 Longitude 57° 08' 55.36"W.

The program used is publicly available on the Internet from the Geodetic Survey of Canada. To assess the accuracy of this program and more particularly the deflection of the vertical coefficients used by the program, the Hydrographer tested about 80 exploratory astronomic sites in northern Canada which also have known WGS-84 positions. That analysis indicated that the accuracy was about ±2.5 seconds of arc in latitude and about ±7.5 seconds of arc in longitude. If the 1936 observations were done using stars transiting the meridian, as is often done for LaPlace azimuth stations and deflection of vertical determinations, then accuracies in the order of ±1.6 seconds in latitude and ±2.5 seconds in longitude, based on 20 Laplace azimuth stations in Canada. For simplicity, not knowing the method of observation and for differences caused by the latitude of Guyana and Suriname versus Canada, the Tribunal's Hydrographer assumed that the values were accurate to ±5 seconds.

Therefore, the Tribunal's Hydrographer was faced with 2 computed positions which were 214 metres apart, and a GPS determined position which was 534 metres from the transformed astronomically determined position and 382 metres from the position derived from the nautical chart. All of these separations were greater than expected. See Figure 4 for a sketch of the geographic relationship of these position determinations. The uncertainty in the location of Marker "B" translated into a lateral uncertainty in the location of the maritime boundary as claimed by each Party, in the order of 215 metres.

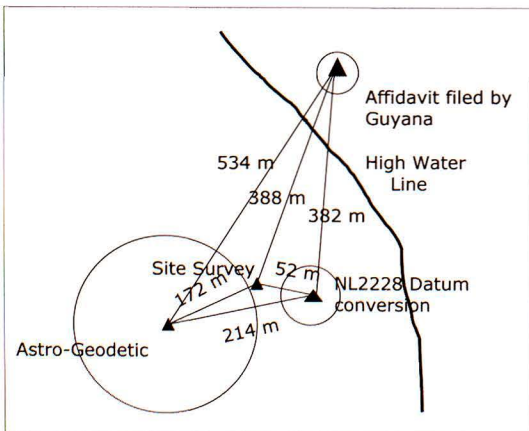


Figure 4: sketch of the geographic relationship of these position determinations.

This uncertainty in the areas claimed was in the order of 80 square kilometres (215 m x 370.4 km) since both Parties were claiming a boundary that was a single rhumb line from the starting point at the Low Water Line to the 200-nautical mile limit. For the delimitation as awarded by the Tribunal, the maritime area involved was 5.2 square kilometres, being a trapezoid of 2.74 square kilometres from the starting point at the Low Water Line to Point #2, and a triangle of 2.46 square kilometres from Point #2 to Point #3. Point #2 is the intersection of the N10°E line through Marker "B" and 3 nautical miles from the Low Water Line of Guyana. Point #3 is the intersection of the 12 nautical mile territorial sea limits of Guyana and Suriname. See Figure 5, where the area of uncertainty is bounded on the Northwest by a solid line and on the Southeast by the line of dashes with cross bars – for a hypothetical, alternate, position of Marker "B" which is farther west.

**The Parties' Correspondence: Disagreement Revealed**

The replies from the Parties to the Tribunal's Hydrographer's requests resulted in a series of letters from the Agents to the Registrar which are fully explained in paragraphs 111-126 of the Award and summarized here.

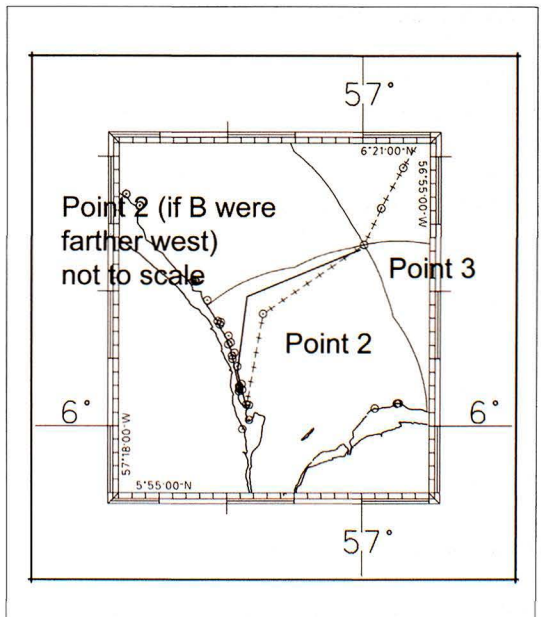


Figure 5: area of uncertainty.

Guyana provided the WGS-84 coordinates for the monument it claimed was Marker “B”, obtained from a 2004 GPS Survey. Suriname reported that it had been unable to find any of the requested information, contested the use of the WGS-84 coordinates for Marker “A” provided in Guyana’s Memorial since it could not verify them, and urged the Tribunal to use the astronomical coordinates previously used by both Parties as the WGS-84 coordinate values. Guyana argued that the Tribunal should reject Suriname’s proposal to use astronomical coordinates for Marker “A”, and claimed that there was no ground to assume that Marker “B” was no longer in its original location and that there was no need for any data in support of its positioning of Marker “A”. Suriname argued that there was no evidence that what Guyana alleged was Marker “B” was indeed Marker “B” or that it was in its original location, and contended further that a site visit would not answer the question whether Marker “B” is its original location. Guyana then offered further arguments regarding the discovery and location of Marker “B” and evidence in the form of two affidavits, which Suriname requested that the Tribunal disregard. To resolve this controversy, the Tribunal informed the Parties that a site visit would be arranged. The Hydrographer’s terms of ref-

erence for the site visit were to inspect what Guyana alleged to be Marker “B” and the surrounding area, as he deemed appropriate, and to gather data relevant to the issues that had arisen as a result of his question to the Parties of 20 December 2006 and the Parties’ subsequent correspondence.

On 31 May 2007, the Hydrographer conducted a site visit in Guyana, accompanied by the Registrar and the representatives of the Parties. On 4 July 2007, the Hydrographer’s “Report on Site Visit” was sent to the Parties, who were invited to provide comments on it. Suriname submitted its comments accepting the Hydrographer’s conclusions and suggesting certain corrections. Guyana accepted the Hydrographer’s conclusions and the changes suggested by Suriname. On 30 July 2007, the Hydrographer submitted a “Corrected Report on Site Visit” reflecting Suriname’s suggested changes, which was circulated to the Parties.

### Elements of the Site Visit

As the Hydrographer saw the matter, his goals were, if possible, first to establish whether Marker “B” was in fact the correct monument and whether it was in its original position; second, to determine its WGS-84 position accurately and with confidence that it was indeed correctly determined; and third, to confirm the geodetic datum shift for Dutch chart 2228, and to establish the geodetic datum shift for British Admiralty chart 99.

The 1936 Mixed Boundary Commission report provided dimensions for Markers “A” and “B” and their associated Pillars. The day prior to the actual site visit, the Guyana Department of Foreign Affairs arranged that the top areas of Marker “B” and Pillar “B” were exposed for inspection. Upon arrival at the site on 31 May 2007, the Tribunal’s Hydrographer measured the monuments and the depth of overburden. The southeast and southwest faces of the Pillar were supposed to be inscribed with “B” and “1936” respectively, but these were not visible at the time. Therefore, the Tribunal’s Hydrographer requested that more of those faces be exposed while other work was being done. Upon revisiting the site at the end of the working day, the Tribunal’s Hydrographer found that the inscriptions were indeed on those faces. All measurements with respect to size of the monuments, and distances between them



Figure 6: Marker ‘B’



Figure 7: Field survey.

were correct, and the location of inscriptions and a brass bolt were in their proper places. The only information that was at variance with the 1936 report was the amount of overburden. There was about 65 cm to 80 cm extra overburden. The sides of the holes indicated that there were tree roots in the soil above the two monuments. It being the rainy season and the soil being sandy, the water table was above the level of the top of Marker "B", necessitating bailing water out of the hole to view it. See Figure 6 for a picture of the top of Marker "B".

As much as the Tribunal's Hydrographer took these measurements and saw the overall physical conditions, he was really only the eyes of the Tribunal. He reported his observations to the Tribunal for its decision. His experience as a cadastral surveyor provided him with knowledge to make recommendations concerning the stability of the monument.

To aid the Tribunal's decision and to aid the governments of Guyana and Suriname in later years, the Hydrographer located the monuments with respect to the nearby trees and fences. The resulting plan of survey was included in the Site Visit Report. The Hydrographer also took photographs of the area to

show the Tribunal the physical situation.

The next goal of the site visit was to determine the precise WGS-84 position of the alleged (later ruled to be) Marker "B". The Hydrographer chose to use a single frequency Magellan Pro-Mark 3 receiver, and to occupy the survey point for a minimum of four hours. The expected accuracy (shall we call it the internal precision?) was estimated at about 20 centimetres. To get significantly better than that would have required many more hours of occupation and the use of a dual frequency receiver. The rented equipment came complete with a second identical receiver so that it could be used to occupy other locations and determine their locations relative to the base station by differential GPS positioning techniques. The reference Pillar and the one remaining footing of the Beacon were positioned this way. As a precaution, instantaneous readings of the GPS position were recorded manually from time to time, just in case the data being recorded electronically was somehow corrupted. See Figure 7.

These values were computed using the Geodetic Survey of Canada's on-line Precise Point Positioning software and were based on the GPS satellite orbit-

al parameters as derived from actual observations taken at tracking stations world-wide. The Hydrographer had to wait 21 days after the day on which the observations were taken for the orbital parameters to be come available before he could compute the final WGS-84 ITRF05 values for the points occupied. These were:

Latitude = 5° 59' 46.2059"N ( $\pm$  0.077 metres)  
 Longitude = 57° 08' 50.4824"W ( $\pm$  0.101 metres).

Although the Site Visit Report only indicates that the base station was computed this way, all stations were computed this way to check on the differential positioning computation and to determine the stand-alone positioning accuracy. The Hydrographer attempted to find another GPS computing service which would also compute the final values for the base station. Unfortunately, the U.S. National Geodetic Survey's facility required the input of dual channel data, and therefore the data collected by single frequency receivers was inadmissible.

The differential positioning computation was done using the software provided with the Magellan receivers, which required the precise position of the base station, as opposed to the position computed by the Magellan software using the broadcast orbital parameters of the GPS satellites.

To prove that the GPS receivers were working correctly before and after the site visit, the Hydrographer occupied a known precise GPS survey point near his home in Ottawa, Canada and then computed its position using the broadcast and then the precise orbital parameters. The positioning accuracy after one hour of occupation was in the order 15 cm in latitude and longitude whereas the positional discrepancy from the published values was less. The decision to use the precise orbital parameters for this Canadian point narrowed the disparity between his surveyed position and the accepted value to within the precision estimate provided in the position computation. He felt that this whole exercise was essential in establishing the credibility of the GPS results obtained in Guyana.

The resulting precise GPS location for Marker "B" proved to be between the position computed from the Dutch chart and from the astronomic position in such a way as to be only slightly beyond the anticipated accuracies of these two methods. The GPS

position filed by Guyana in an affidavit proved to be 388 metres from the Hydrographer's determination. Guyana, in its letter accepting the results, attributed the differences to type of GPS equipment, length of occupation, and computational processes used.

The site visit was next used to determine the location of features visible on the British Admiralty and Dutch charts of the Corentyne River. At the time of the site visit, the Hydrographer did not know how the Tribunal wished to carry out the delimitation in the river mouth. There was the possibility that it might wish to use the Low Water Line of one, or both, of the nautical charts, and the Hydrographer would thus be required to determine locations from those charts and to convert them into WGS-84 datum positions.

The determination of the datum shift was done by determining the WGS-84 position of features visible on the charts and then comparing those positions against the charted locations. This worked quite well except that the comparison at one location – Rest House 63 – proved to be significantly different than the other locations. It was assumed that the wrong building was positioned. The fact that the wrong building was visited had repercussions in the search for the astronomic station mentioned in the Boundary Commissioners' 1936 Report. In it, the astronomic pier was referenced to the building, and a search for it – at the wrong building – had not found it. The resulting datum shifts were:

For BA 99	Mean	+1.65"	-1.70"
	Standard		
	Deviation	$\pm$ 0.93"	$\pm$ 0.74"
For NL 2228	Mean	-12.22"	+6.64"
	Standard		
	Deviation	$\pm$ 1.54"	$\pm$ 1.57"

Once the survey work was completed in Guyana, the Hydrographer took the precaution of faxing the rough field notes to the Permanent Court of Arbitration's offices in The Hague. The Registrar, Mr. Brooks Daly, returned from Guyana with a copy of the rough field notes as a further precaution.

After the Tribunal made public its Award, the Hydrographer considered that the British and Dutch Hydrographic Offices would benefit from access to the technical facts derived from the site visit. The Parties in the deliberation agreed that the Site Visit Report could be made public and thus the Hydrogra-



pher passed along to the Hydrographic Offices that report. Salient information that they might glean from the report are: that the charted beacon should be expunged from the charts, and that there is information determining the datum shift for British Admiralty chart 99, and confirming the datum shift for Dutch chart 2228.

### Acceptance of the Report

The Hydrographer had to wait three weeks for the precise orbital parameters before he could finalise his computations. Then the Report was reviewed by the Tribunal, and then circulated to the Parties, who accepted it after some typographical errors were corrected.

### The Future of Marker “B”

Erosion of the shore may destroy Marker “B” and its associated reference pillar in as little as 25 years, given the rate of erosion since 1936. Given the prima facie rule of property surveying, that the physical location of an undisturbed boundary marker is the best evidence of a boundary, steps to preserve the boundary markers and to add other markers along the extension of the maritime boundary farther in-shore could be considered.

### Conclusions

The Hydrographer applied his experience in cadastral surveys and geodetic triangulation in recovery of old survey monumentation. He applied his experience in carrying out a site plan to assist the Tribunal in its decision and for the governments of Guyana and Suriname in maintaining this important boundary marker. He attempted to have a check measurement for as many of the survey elements as possible: taped measurements checked by GPS, prismatic compass bearing checked by GPS, GPS equipment checked at a known location, one GPS receiver checked against the other, and the filing of the field notes by fax back to the offices of the Permanent Court of Arbitration immediately after the survey

The survey removed the uncertainty in the geographic location of the boundary reference point, which

had been established in 1936, and thus removed the uncertainty in the allocation of some 5.2 square kilometres of maritime space awarded by the Tribunal within the territorial sea.

The author trusts that he has honored Commander Beazley’s words of advice to check and re-check whatever he did. Although this site visit does not explicitly set survey standards, it could serve as useful precedent for other Tribunal Hydrographers faced with a similar task.

### References

Arbitration between Guyana and Suriname (17 September 2007), online at <http://www.pca-cpa.org/> .

Tribunal Hydrographer’s Site Visit Report, online at <http://www.pca-cpa.org/upload/files/THCSiteVisitReport.pdf>

### Biography

While studying surveying at University of Toronto, **David Gray** worked for an Ontario Land Surveyor doing property surveys, architectural site plans and quantity surveys (size of excavations). Upon graduation, he did first order geodetic triangulation reconnaissance where he recovered survey points established 60 years previous. Going back to graduate school, his thesis dealt with error propagation through triangulation nets as a means to set survey standards. He then transferred to the Canadian Hydrographic Service where he worked on Decca and Loran-C velocities over different mediums and geodetic datum transformation of the nautical charts and surveys. He was also involved in maritime boundaries and limits for over 25 years, including the re-computation of 1500km. of the Canada-Greenland boundary and being the technical expert assisting the tribunal in the Nova Scotia-Newfoundland & Labrador offshore resource boundary. Since leaving CHS, he has been the Tribunals’ technical expert in the Barbados-Trinidad & Tobago and Guyana-Suriname maritime boundary arbitrations at the Permanent Court of Arbitration.

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