NRAO ONLINE 44

GRT 1958: Freeman, Fox and Partners, Consulting Engineer for the GRT, Site Selection Process, Trouble with FFP, Bowen's "shock" visit ("Tailtwister I") to FFP, November 1958.

Epigraph

> [Roberts of FFP] is undoubtedly a great engineer, but his idiosyncrasies do not make for the smooth and efficient working of the project. He also has great difficulty in answering a direct question. He infuriates the people at Metrovick. He does not get on at all with Metrovick who after all are going to be the main contractors on the job.

24 December 1958, Bowen to White after "Tailtwister I " visit to the UK

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The year 1958 began with a burst of optimism in Sydney as the GRT Technical Advisory Committee (TAC) prepared for Gilbert Roberts's visit, beginning 13 January 1958. Bowen wrote Pawsey on 3 January [1] with an upbeat assessment of the expected status after Roberts's upcoming visit in January 1958: I am hopeful that all the relevant issues will have been resolved to the point where we will be able to ask FFP to go ahead with a specific design [of the GRT] of a definite size.

The TAC met on 6 January 1958 to prepare in detail for Roberts's visit. William Wittrick (professor of aeronautical engineering at the University of Sydney) reported on a meeting on 11 December 1957 at the Aeronautical Research Laboratory in Melbourne with a summary of the detailed examination of the FFP study carried out by this organisation, under the leadership of the mathematician and prominent authority on the properties of aircraft materials, J.P.O. Silberstein.[2] The general impression was "that the claims made in the final report should be accepted with confidence. Several matters should, however, be raised with FFP…. there were not major factors in the general feasibility." Numerous details were discussed. Since it was now clear that the GRT could be used at short wavelengths (certainly 10 cm and perhaps 3 cm); the mesh design would need to be constructed with a spacing of about 1 cm instead of 2.5 cm, also

[1] NAA, C3830, F1/4/PAW5. The letter was written before Bowen had received Pawsey's 28 December 1957 comments on the design study of FFP.
[2] NAA, C3830, A1/3/11/4

smaller wires were required for the mesh to enable higher frequency use of the GRT. The committee also expected that the contractual arrangement for the construction and later the final acceptance of the GRT would need to be formulated "after the various technical matters relating to the structure itself have been settled". [3]

In his letter to Pawsey of 13 January 1958[4], Bowen thought that the likelihood was: (1) that RP would go along with the alt-azimuth design and (2) that RP would settle for a diameter of around 210 feet. Bowen assumed that the Rockefeller Foundation might contribute additional funds, " … but I am not inclined to follow this at the present stage. I think the right tactics are to keep the Rockefeller possibility as a back-stop in case the bids from contractors turn out to be very much larger than Freeman Fox's estimates [this is exactly what occurred in 1959]… and (3) to use a finer mesh than FFP had proposed and an f/D of 0.41. [the dimension of the focal point above the dish compared to the dish diameter]

Bowen hoped to settle all of these issues in the first week of February 1958 and then obtain official CSIRO approval for plans that would lead to the tender activities leading to construction.

At the conclusion of the letter, Bowen faced two major remaining questions: (1) where was the GRT to be located? (2) Who would lead the project on a day-to-day basis, supervising the details of contracts, site acquisition and construction with special emphasis on adherence to time scales? Bowen wrote Pawsey[5]:

> It is the easiest thing in the world for a project of this kind to bog down unless someone is pushing hard the whole time. I am certainly not the one who will do this if the GRT goes to Canberra. Arthur [Higgs] and McCready have both said that they are not going to do it and no one in the radio astronomy group has yet volunteered. **This leaves you [Pawsey]. Are you prepared to take it on?** [our emphasis][6]

On 16 January1958, Bowen was joined by Prof Jack Roderick, Prof William Wittrick, Dr Hugo Messerle and Arthur Wills along with Arthur Higgs, Bernie Mills and Paul Wild of the RP staff as the TAC committee began extensive deliberations with Gilbert Roberts of FFP. The plan for the next few weeks was discussed with the goal of setting the contractual arrangements required

[3] Bowen had also tried to elicit comments from Barnes Wallis about the FFP report of late 1957 to be discussed with Roberts. Bowen must have assumed that Wallis's possible favourable comments would impress the Minister, Casey. Wallis had had little time to read the report and more importantly his contacts with FFP were coming to an end. Details of the communications with Wallis are described in Additional Note 1.

[4] Pawsey archive, CASS (via Ron Ekers), earlier provided to Ekers by Sally Atkinson.

[5] Bowen pointed out to Pawsey that this question "may be the most important one".

[6] This request shows the increasing level of conflict between the senior leaders of RPL. Within the next few years, these disagreements were to increase finally leading to the break in 1960-1961.

to build the GRT. Roberts summarised the history of the design study with Barnes Wallis's idea of a "compensated structure in light alloy, with a master control unit". Early in the process FFP discovered that the specifications of the GRT could be fulfilled with a non-compensated steel structure using a master equatorial and a centrally supported structure. "Freeman Fox always favoured the use of an alt-azimuth mounting in conjunction with a master control, and had only considered the equatorial [mount] in some detail as a result from pressure from CSIRO." (All quoted text is from the TAC minutes NAA C3830 A1/3/11/4 16 January 1958.)

Bowen pointed out that any diameter in the range 200-250 feet was desirable. He admitted that they were not interested in a size less than the symbolically important 200 foot diameter boundary. RP was only "interested … in scientific results to be obtained, not in size for its own sake, … surface and pointing accuracy were equally important". Bowen conceded that the equatorial design was off the table. Also there was discussion of the central 66 foot diameter solid surface of the GRT and the impact this might have for future high frequency observations.

The use of the GRT at 3 cm was the subject of a long discussion. "Dr Pawsey and Mr Kerr had both suggested that we should try to aim for operation at 3 cm. It was agreed, however, that we should concentrate on insuring good use down to 10 cm, but do whatever might be feasible to allow use at still higher frequencies, particularly the central section." (See the letter of 28 December 1957 , Chapter 27 and NRAO ONLINE 43, Pawsey to Bowen about high frequency use of the GRT).

As outlined by Roberts, the arrangements for construction were, at this time, quite complex.[7] A prime contractor was not feasible (14 January 1958):

> …since no single firm would be supplying more than 30 per cent… Metropolitan-Vickers had agreed to accept responsibility for the whole of the control and drive system, for the hub and turret structures and for assembly, testing and trials in Great Britain before dispatch to Australia. They would sub-contract the master control system to Grubb Parsons and the turret structure to Sir William Arrol and Company. The construction of the foundations and tower would be a separate contract; the third contract would be for the construction of the dish and its erection at the site. He [Roberts] foresaw no difficulties in this arrangement since each contractor would be working independently and commence when the earlier phase had been completed.

At the end of the TAC meeting with Roberts, 29 "action items" were identified consisting of the component item (e.g. "tower of the GRT"), the action to be taken and the person or

[7] NAA C3830, A1/3/11/4, minutes of TAC 16 January 1958.

organisation that would be responsible. Clearly by mid-January 1958, RP and FFP were close to converging on an amicable agreement.

On 6 February 1958, Gilbert Roberts of FFP went with White and Bowen of CSIRO to a meeting in Melbourne with the Minister for the CSIRO, R.G. Casey; Roderick and Wills of the TAC were also present. Roberts provided two presentations: (1) description of the alt-azimuth design and estimates of costs and (2) outline of the contract for construction and erection with an estimate of the erection time. Bowen provided a summary of the TAC comments from the previous week's deliberations in Sydney.

On 7 February 1958, White sent a summary of their meeting of the previous day to R.G. Casey, Minister for the CSIRO, as well as a report on the financial status of the GRT project.[8] In particular, White reported that Bowen anticipated that more funds would likely be required when the contracts for construction were let; Bowen was certain that it was prudent to wait until that time to request more funds from the US foundations. On 25 February 1958, White began the negotiation[9] with FFP for the "actual construction and erection of the radio telescope"; FFP were to be the "Consulting Engineers in the matter of consideration of the tenders received and the supervision of the actual construction". White expected that the contracts could be let in 6-9 months. In addition, White requested that FFP provide a time scale for the final completion of the GRT.

Site Selection of the GRT – 1953 to 1958

The final selection of the site at Parkes by the CSIRO authorities on 17 March 1958 marked the end of an arduous search that had started in 1953 and intensified in 1957. There were numerous options as well as a number of opinionated participants within CSIRO.

Robertson (1992) has provided a thorough description of the process. Here we will follow his treatment with additional details. The site had to fulfil a series of obvious requirements: (1) able to support a heavy structure of up to 2000 tonnes, (2) possess a mild climate with no ice or snow, (3) especially be free of heavy radio interference caused by nearby radio transmitters and (4) be a region of low population density with few vehicles and free of industries. Other issues came into play such as convenience for the staff and political factors (e.g. proximity to Canberra and the Australian National University). As Robertson has written: "The issue settled down into a three-way contest – a site close to Sydney (a favoured site was near Camden), one near Canberra, or a third 'over the mountains' well to the west of Sydney [at distances of some

[8] NAA, C3830, A1/3/11/3, Part 4. This included a number of questions that Casey had raised on 6 February 1958. An example was "What would be the optimum size of [the] dish….together with accuracy on the present design?"
[9] RPL archive at CSRIO, CASS, Marsfield

hundreds of km]."(The final selection of the site at Parkes will be described later in this text and NRAO ONLINE 48.) In the 1950s, the model for RP field stations (such as Dover Heights, Potts Hill, Fleurs, Hornsby and Penrith) had been established. These were close enough that daily visits from the RPL headquarters on the University of Sydney campus were possible while development of the equipment and data reduction could take place at the lab. There was one exception, the solar site at Dapto near Wollongong at a distance of about 100 km, wherePaul Wild and colleagues had developed the swept frequency instrument in the early 1950s. The site contained simple accommodation, with the personnel spending about a week at the site between visits to the Sydney RPL. For the GRT the possible sites near Sydney could have functioned in a similar fashion as had been the case at the field stations.

One of the first attempts to gather information about possible sites within 65 km of Sydney was initiated by Pawsey in 1953 (22 January 1953)[10]. He wrote the New South Wales Department of Mines in Sydney after a discussion with a member of the Geological Survey Section, inquiring about geologically suitable sites. After this colleague suggested several possibilities, RP staff investigated these locations. Pawsey asked if additional detailed geological advice could be obtained during a joint visit with RP staff over three to four days at a number of locations close to Sydney. By 24 February 1953, a report was sent to Pawsey with details of sites at Malgoa (66 km west of Sydney at 120 metres elevation, South of Penrith) and Woodford (90 km west of Sydney in the Blue Mountains at an elevation of 550 metres). The former site was 32 km north of the Camden site, an "unstable site" with some "erosional gullying". The latter site was in a small valley, from a geological perspective unsuitable for later investigations by RPL personnel.

The moment a public announcement of the Carnegie Corporation grant in mid-1954 was made, numerous landowners and estate agents wrote to Bowen with suggestions for GRT sites in their own districts. For example, a site near Brisbane Water, north of Sydney near Gosford was proposed, clearly not a suitable location. Politicians even wrote the Minister for the CSIRO requesting information about possible sites. A most unusual request came to Sir Ian Clunies Ross, the Chairman of the CSIRO in November 1954: his former secretary at the University of Sydney Veterinary School, Miss Beatrice Black, owned a small property near Wiseman's Ferry, 90 km north of Sydney. Clunies Ross told her there was considerable doubt that the GRT project would go ahead; she was insistent and Clunies Ross sent a second discouraging letter to Miss Black, likely a strategy to prevent property speculation.

Bowen (following a phone call from Frank Kerr of the RP staff) inquired at this point of the Australian Overseas Telephone Commission for assistance with finding sites; the assumption was that their requirements for siting an aerial would be similar to the GRT's. Although the frequencies were well below any plausible radio astronomy observing frequency for the GRT

[10] NAA, C3830, A1/3/1/5A, Part1.

(515 kHz, 5 and 15 MHz), RP was interested in low radio frequency noise levels, flat land and proximity to services such as mains electricity supply (the AC power system at 230 v). OTC sent along descriptions of 16 sites near Sydney, including those close to the Camden sites, including the site which was subsequently given serious consideration, Bringelly (20 km north of Camden).

On 16 November 1955, Pawsey, Lindsay McCready and George Day visited Katoomba in the Blue Mountains to meet the mayor, town clerk, city engineer and the deputy electrical engineer. None of the four sites was suitable due to a lack of shielding and restricted land area. A month later, George Day went on a DC-3 flight to photograph possible sites in Camden, Mittagong, Moss Vale, Kangeroo Valley, Nowra and at the Cordeaux and Cataract Dams. Some months later (4 May 1956), he took a short flight in a single engine aircraft (Auster) to investigate the Camden sites, including the one at Cliffdale. (see below for details)

By February 1956, George Day and Lindsay McCready had investigated several sites on the western side of the Blue Mountains at distances of 170-200 km from Sydney. These included a 4 square km area near Bathurst, 200 km from Sydney. During March 1956, Day and McCready (supervised by Pawsey) produced a detailed report of their investigations of six sites, out of an original list of 33 potential sites:

(1) Fleurs (50 km from Sydney)
(2) Greendale near Bringelly (56 km)
(3) Camden (61 km from Sydney, about 25 km to the south of Greendale)
(4) Mittagong (105 km)
(5) Moss Vale (120 km)
(6) Hoskinstown near Canberra (290 km, characterised as the “ideal site”).

All sites were relatively flat locations, with the last three outside the daily working range from Sydney. Fleurs was already an existing RPL field station. Radio frequency interference tests had been carried out at Fleurs, in the Camden area and Moss Vale at 62 MHz (noise tests) and in the range 40-140 MHz to detect broadcast stations. All three sites were reasonably “quiet”, with some light aircraft detected.

By 2 February 1957, Bowen felt secure about the Camden Nepean River sites; he favoured the Cliffvale location on the Nepean River about 8 km NE of Camden. This was a property, “Cliffvale”, owned by H.C. Anderson on Werombi Road; about 50 acres would be needed. In a letter to White, Bowen wrote:

> [The sites] derive their suitability from the fact that they are situated on low and flat land in the Valley of the Nepean River. Their low height above sea level, together with the existence of higher ground to the East and North-East, will almost certainly combine

> to produce an adequately low noise level at the site, which is, of course, the vital and overriding requirement; the surrounding terrain is essentially flat for at least ½ mile in the North-South and East-West direction, so that facilities for spaced-aerial interferometry would be available if required.[11]

Two obstacles stood in the way of the acceptance of the Cliffvale site. The RP staff was unenthusiastic, likely fearing that industrial expansion to the west of Sydney would accelerate in the near future. A further roadblock was the presence of the new CSIRO Upper Atmosphere section located in Camden, a distance of less than 10 km. A component of the research of this group consisted of an investigation of the properties of the ionosphere using low frequency radar transmissions. The nemesis of RP, David F. Martyn, raised objections in a letter to Stewart Bastow, the CEO of CSIRO from 1 January 1957 to 30 June 1959.[12] In mid-August 1957, Martyn pointed out to Bastow that "nearly all our work demands and uses powerful pulse transmissions on many frequencies, which would be almost certain to interfere with the operation of the giant radio telescope placed so near to us as is apparently contemplated…. [It] would be the height of folly to erect a radio telescope within a few miles of a centre concerned with pulse sounding of the ionosphere."[13] (Details of David Martyn's controversial career are given in NRAO ONLINE 7.) During this period, Christiansen, Mills and Wild would have looked at a number of sites near the Neapean River; these three were photographed by George Day in this era as shown in Fig 1.

White was informed by Bastow of the Martyn letter and wrote Bowen on 14 August 1957[14]. White presumed that RP had considered the proximity of the Cliffvale site to the Camden Radio Research Board (RRB) transmitters:

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[11] NAA C3830 A1/3/11/10, Part 2. On 22 March 1957, Lindsay McCready provided Harry Minnett in London with more details. "This decision has been unanimously agreed to by the Executive Committee [of CSIRO] and RP, as the difficulties of operating at noise-free sites 'over the hills and far away' are too great. We have therefore assumed that no low-level observations will be carried out at frequencies below 500 MHz in these areas, as the noise level… will not permit it. … It is quite attractive from a scenic point of view and handy to pubs [!], shops and schools at Camden. You will note that is only a few miles further along the Werombi from the RBB [Radio Research Board] Station. Note the shielding from Sydney north-east of the site…. Test borings for geological information will commence after the noise tests and when the owner formally agrees to sell us a portion of his land…." RPL was not worried about flooding and investigations of the wind conditions were to begin. "Finally, I do not wish to give any impression that the site is a tricky one. It is sheltered considerably and should have longer periods of low winds than Sydney, but we must, of course, examine every possibility when an instrument costing half a million [pounds] is to be erected there."

[12] Stewart H. Bastow, a physical chemist, died on 23 January 1964, having served on the CSIRO Executive from May 1949 until his death. He was CEO of the CSIRO from January 1957 to July 1959.

[13] CSIRO archive, TZ/797/2.

[14] *Ibid*

> It is, however, worthwhile reflecting that a site for the telescope should not be selected which, because of interference, would cause difficulty for the RRB or for Radiophysics in that any radio developments on either side might interfere with the other. This, I think, is an added reason for considering Canberra [Hoskinstown].[15]

The RP staff did know about this situation and thought it would not be a problem. Arthur Higgs, the Technical Secretary of RP and George Munro of the CSIRO Radio Research Board, in the Electrical Engineering Department at the University of Sydney, exchanged letters on 15 August 1957 (Munro to Higgs) and 19 August (Higgs to Munro).[16] Munro pointed out in detail the exact frequencies[17]: "[We assume] that you are satisfied that the [transmissions from the Camden station] will not interfere with your observations [with the planned GRT] as the ground rays seem likely to be of considerable strength at your site." Higgs wrote back:

> We were, of course, aware of these transmissions except of those proposed on a frequency of 515 Mc/s [a proposed pulsed transmission UHF radio link between Camden and the Sydney University department] and we do not expect them to cause any interference since we anticipate that the GRT will be operated almost exclusively at frequencies of 600 Mc/s and higher. I do not think your proposed high power transmissions at 515 Mc/s would likewise cause any trouble, unless a harmonic of them happened to fall on some specific frequency such as the hydrogen line [1420 MHz], in which case presumably some appropriate action could be taken.

Apparently as far as RP was concerned the RRB location was not a problem; no future mention was made of possible environmental threats.

During 1957, there were danger signals about the possibility of flooding near the Nepean River between Camden and Wallacia. Gilbert Roberts had expressed fears about this issue and in early May the Metropolitan Water, Sewage and Drainage Board of Sydney sent a detailed report about the likelihood of flooding at the two favoured locations, including Cliffvale. A

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[15] NAA, C3830, A1/3/11/5A, Part 1. White seemed to have been worried about the continued poisonous relation between Martyn and Bowen which had been an ongoing irritant since the 1940s. Robertson (1992) has suggested that if any conflict would arise in the future over the two adjacent sites near Camden that RP would prevail due to the large investment and prestige of the GRT. Also Martyn had written Bastow with a summary of the conflicts he had experienced such as the "decision [in the early 1950s] of the Executive to oppose the development of radio astronomy at Stromlo… and of the hard but finally successful struggle to convince the Executive that the site and existing buildings [at the new Camden site] provided an economic and suitable site for our work". (TZ/797/2). At this time the RRB had fixed frequency pulsed transmitters in the HF band (3 to 30 MHz) with powers of a few kilowatts; in late August 1957 "backscatter" came into operation at 11.6, 17.55 and 30 MHz.

[16] *Ibid*

[17] *Ibid*

carefully worded, noncommittal report was provided to RP. Comparison was made of a recent flood (11 February 1956) with two major historical floods of 1867 and 1873. The experts did suggest that there was a real but unlikely possibility that severe flooding might occur; the 1867 flood would have covered the centre of the Cliffvale site. Of course the newly built dams in the Nepean catchment area would lead to "a lower flood level in the future for storms similar to [the late 19century events]".[18]

At the end of December 1957, Pawsey wrote Bowen from the US[19] with a strong plea for the choice of the Hoskinstown site near Canberra:

> I consider the Camden site to be usable but marginal and think it would be best to choose a good Canberra one, e.g. Hoskingstown [sic]. I base this on the grounds of a much smaller anticipated noise level but I would not be prepared to move to an alternative quiet site far removed from any scientific society. In view of the apparent reluctance of RP staff [including Mills and Christiansen] to leave Sydney I favour the idea of operating Canberra as an outstation for a number of years using Sydney as the main base. But in time I anticipate a complete move to Canberra would be the best thing. I particularly place value on the contact with the small scientific group in Canberra, astronomical and [with the physicists].

Bowen[20] disagreed :

> One of the most important reasons for the success of the radio astronomy group is that it has had a pool of exceptionally well qualified people to draw on from the Radiophysics Laboratory, excellent workshop facilities etc. [The Australian National University in Canberra] can certainly offer an academic atmosphere and some good lunches, but where is the hard core of people who can be drawn on to get on the business of radio astronomy?

A few weeks later (31 January 1958) Bowen had a new theme, signalling a new point of view about the site issue[21]:

> I have consistently taken the view that our radio astronomers[22] are the ones who are going to get the benefit of the radio telescope and it is their responsibility to choose the site. [Bowen had, however, written Pawsey on 13 January [1958] with a plea for a site

[18] NAA, C3830, A1/3/11/5A, Part 1.
[19] NAA, C3830, A1/3/11/1, Part 9.
[20] NAA, C3830, F1/4/PAW5, 13 January 1958, to Pawsey from Bowen.
[21] NAA, C3830, A1/3/11/1, Part 10, to White with copy to Pawsey from Bowen.
[22] The omission of outside RP use of the GRT ("open skies" or a description as a "national asset" is striking. of "open skies" or even a "National" asset.

close to Sydney.] As is usual they are having extreme difficulty in making up their minds… We have been waiting for two years for the radio astronomers to make up their minds, but at the moment we are no nearer to an agreed solution.[23]

On 4 February 1958, Bowen wrote Pawsey at the Sac Peak Observatory in New Mexico in care of Jack Evans.[24] He thanked Pawsey and Frank Kerr for their useful advice about the GRT plans as RP had prepared for Roberts's upcoming-visit to Sydney in January 1958. Pawsey and Kerr had met in Princeton, New Jersey, for discussions in late December 1957 (Chapter 27 and NRAO ONLINE 43). "It is a pity [Bowen wrote Pawsey] though that you are not around in person when some of the more important decisions affecting the Radio Astronomy group are being taken." Bowen reported that Roberts and FFP had asserted that the lack of a site decision was the major "obstacle preventing an early start [on the construction of the GRT], and the fact that the decision has not been taken leaves us at a moral disadvantage in pressing FFP to get on with the project with the necessary urgency". As we will see this claim on Bowen's part was exaggerated. Bowen continued, "The anti-Canberra boys are in full cry and they are doing a final [tour] around the countryside this week. It would be really refreshing if the group came up with a firm, definitive and unanimous decision once in a while."

Bowen also complained to White (20 February 1958[25]) about Pawsey's lack of input on the GRT discussions: "The immediate need for Joe to return has evaporated, as the major decisions on the GRT have now been taken." (This referred to the discussions with FFP and Roberts in January 1958.) Pawsey had, in fact, provided valuable input, as acknowledged by Bowen on 4 February 1958. Bowen continued: "He could still contribute on the question of the site, but I have written to him on this and he is maintaining a stony silence." Again this criticism is unfounded given Pawsey's detailed letter of 28 December 1957 in which he came out strongly in favour of the Canberra (Hoskinstown) GRT site.

Two letters in the following weeks (Pawsey to Bowen 23 February[26] and Bowen to White 5 March 1958[27]) continued the confused exchange between the two colleagues, Pawsey and Bowen. Bowen's letter to White contained a number of inaccurate statements. Apparently, Bowen had begun to have doubts about Pawsey's judgement and was becoming impatient with Pawsey's management style. This impatience was to continue until Mills's and Christiansen's resignations in 1960 followed by Pawsey's resignation in late 1961 (see Chapters 30 and 38). As expressed in the 23 February letter, Pawsey was pleased with the FFP decisions and discussed

[23] Within a month, Bowen was to see that the radio astronomy group was close to a unanimous decision in favour of the Parkes site.
[24] Deane archive.
[25] NAA C3830 Z1/7/B/2
[26] NAA C3830 F1/4/PAW5
[27] NAA C3830 A1/3/11/5A Part 2.

in detail the site selection process. There was confusion: "I am a little puzzled by receiving a letter from Fred White saying you [Bowen] had told him that a decision on the site could await my return and then hearing from you [4 February] of it being urgent." As explained to Bowen, Pawsey had received letters from both Christiansen and Mills with anti-Canberra sentiments expressed: "[L]argely, I think, because they did not want to live there."

When Pawsey had left Australia the previous August (1957), he had the impression based on the letter of 12 February 1957 that the Cliffvale or one of the other Camden sites looked likely. Bowen had even asked the CSIRO Executive for approval to begin the acquisition process in 1957. Before Pawsey left Australia in August 1957, two other options had been on the table, both about 300 km from Sydney. Cowra, west of Sydney (100 km SE of Parkes) had been identified in the course of 1957 as a possible site. Pawsey wrote Bowen on 23 February 1958 [28]:

> Last August (1957) I had thought we were agreed on the Cliffdale site. We believed this to be good but not perfect with respect to interference, but considered that for a worthwhile improvement we had to go 200 miles [320 km] from Sydney to a place such as Cowra or Hoskingstown [sic] (south of Lake George). We understood from Fred White and Clunies Ross (CSIRO Chairman) that the former was inexpedient and the latter is not a good place for a scientific institution. Then came Fred White's suggestion of the Canberra neighbourhood [actually the same as Hoskinstown. The confusion between Canberra and Hoskinstown remains a mystery. It is not clear if one or two sites were being discussed]. This [site near Canberra] appeared to me to be a good compromise, an adequately low noise level, with reasonable transport and the possibility of improving contact between radio and optical astronomers, - the only group in Australia. I don't know your [Bowen's] reasons for rejecting this part of the country, but you obviously have strong feelings on the matter and I respect your opinion. I gather that Cowra or a similar remote site is again under consideration for use on a field station basis.

Pawsey was worried about this site since he could see that the GRT site would need "constant attendance by the scientific staff", requiring long visits of months' duration. If the staff were not willing to commit to long visits away from Sydney, "I should favour reverting to Cliffdale. It is very difficult for me to come to this debate fruitfully from this distance with my lack of knowledge of what is going on".[29]

[28] NAA C3830 F1/4/PAW/4

[29] In a fascinating comparison, Pawsey looked at the GRT site isolation in light of the discussions in the late 1950s in the US about the remote location of the AUI observatory at Green Bank, West Virginia. "…I find opinion strongly divided. Merle Tuve is strongly against the isolation; others accept it…. Cliffvale

The bottom line for Pawsey was that he was prepared to accept the "Cliffvale compromise. I am a little surprised that the problem has been re-opened but I should be agreeable to going to one of the 200 mile distant sites only if you and the [radio astronomy] group are firmly in favour."[30]

Developments on the site selection process were moving rapidly. In his letter to White of 5 March 1958, Bowen reported that on the morning of 17 March 1958, Christiansen, Mills, Kerr, Wild and McCready would go to Melbourne to meet with Clunies Ross and White (and possibly Bastow) to discuss the siting of the GRT. "I sincerely hope that a final decision can be reached at this time." **Bowen would not attend (our emphasis}**: "With this show of talent, there is not much need for me to come too." Later White tried to persuade Bowen to attend, to no avail. Guy Gresford, Research Secretary, Physical Sciences CSIRO organised the conference on 17 March 1958,[31] the "summit" conference to determine the site of the GRT without Bowen.

Bowen presented his reaction to the Pawsey letter of late February on 5 March 195 to White

(1) "[Pawsey] thought the radio astronomy group had decided on the Cliffvale site last August [1957]. Nobody here seems to know about this decision, but he still thinks it is a good spot." As we have seen, there had been a consensus earlier in 1958 that one of the Camden Nepean River sites would be a workable solution. Next Bowen provided a misleading interpretation of Pawsey's opinions.
(2) "He reckons Canberra (not Hoskinstown) is a good place and will readily agree with it."[The distinction between Canberra and Hoskinstown remained confusing.]
(3) "He thinks 'over the mountains' is a good place and will agree with the boys if that is what they want."

In fact, as we have seen. Pawsey said that he would prefer Hoskinstown, but if Bowen were opposed he would respect Bowen's views. Pawsey would only accept Cowra ("over the mountains") if the scientific staff would commit to long periods of attendance at the remote site. Bowen had given White the opinion that Pawsey was indecisive about the site decision. Was Bowen trying to undermine White's confidence in Pawsey? Perhaps Bowen's strategy was to address proponents of both sides and "divide and conquer" as he split the radio group,

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would be a trifle worse than Green Bank or Owens Valley from an interference point of view, but much better than [Dwingeloo in the Netherlands]."

[30] The nature of the conflict is impossible to assess from the present perspective. The level of confusion was complete; both sides were talking at crossed purposes. Pawsey was not dogmatic and appeared to be agreeable to all sides of the arguments. His absence in 1957-1958 was inopportune during this critical period. Bowen's frustration with his absence was warranted. However, Pawsey was willing to all sides of the arguments and to accede to Bowen's wishes. Also, the second-level experts (Wild, Christiansen, Mills and Kerr) from RP were to play major roles in the final decision (see below).

[31] NAA, C3830, A1/3/11/5A, Part 2.

finally choosing the Camden site? However, in the end Bowen did not do this as he acceded to their choice of a "site over the mountains".

Bowen then gave his opinion about the site selection to White:

> My own views are quite simple. In a country like Australia there are almost an infinite number of sites eminently suitable for a GRT which have the necessary flat ground around them and offer an electrical noise level which is lower than can ever be achieved in the UK, Europe or the USA. We would be foolish to throw away this **national advantage** [mentioned for the first time, our emphasis] and put the device in a noisy area. This means ["a site over the mountains" such as Cowra or Parkes] or somewhere west… [32]

In conclusion Bowen emphasised to White in the letter of 5 March 1958 : "I regard Parkes as the ideal site for the radio telescope…If for any reasons [such as getting closer to civilisation], we cannot go to Parkes, then Cliffvale near Camden is the shot."

The next day (6 March 1958), Bart Bok, the new director of Mt Stromlo Observatory of the Australian National University, made a major contribution to the solution of the site question. In a communication from Bok to Fred White, Bok reminded White that they had had a "conversation a few months ago" about the close connection between the choice of the GRT site and the urgent need for the Stromlo optical astronomers to acquire a new improved observing site away from the cloudy skies of Canberra. On the afternoon of 3 March 1958, Bok met Taffy Bowen and staff in Sydney as they prepared their final recommendation for the GBT site. Bok was relieved to find out that RP had given up on Camden: "… [F]or I can see nothing but trouble ahead with interference if we should have decided on that spot." Bok was favourably impressed by the quality of the Parkes site; he was also surprised and pleased to hear of the "unanimity of support that seems to have developed for Parkes, which is the sort of thing that I had not found at Radiophsycis with regard to sites discussed earlier".

Then Bok brought White up to date on the "the field station developments at Mount Stromlo". Based on the poor observing conditions (December- February) for the Magellanic Clouds, it was realised that a new observatory site with better weather conditions was required. The ANU administration informed Bok that a Western Australia site was prohibitively expensive; thus a new field station within driving distance of the ACT was required. Plans for site surveys were then underway at 10-12 sites within central and North-West New South Wales. (The line Mildura-Broken Hill was the western boundary, they would consider as far North as Bourke,

[32] Details of the choice of Parkes are presented below.

and Parkes "was our southeastern anchor point".) Bok finished with a surprising statement[33]: "For equally good conditions for night observing, we would favour a location near Parkes if it should be that RP sets up its establishment there."

On 12 May 1962, ANU announced that Siding Spring near Coonabarabran (about 280 km north of the Parkes GRT site) would be the location of the new observatory, which opened on 5 April 1965.

Bok suggested that White show the letter to Clunies Ross, the Chair of CSIRO, who was on the Council of the ANU and thus interested in the Stromlo plans.

In the 5 March 1958 letter to White from Bowen, Bowen mentioned his conversations he had had with Bok about the connection between the RP GRT site decision and the ANU field station plans. Bowen did, however, misrepresent Bok's assessment of the quality of the possible Canberra (Hoskinstown) GRT site. Bowen wrote: "On purely personal grounds he [Bok] would like to see the [GRT] near Mount Stromlo." From the context of the Bok letter (of 6 March 1958) it is clear he had **earlier** (our emphasis) been in favour of the Hoskinstown site, but had now changed his mind: "The arguments they [RP staff] advanced against Canberra [Hoskinstown]- which would have been my choice- seemed solid scientific ones. I was shown the plans for TV development (tall towers on top of Mount Ainslie[34]) and future radio lines of communication between Canberra and Sydney. I must admit that Canberra may only be ten or fifteen years behind Camden in showing promise of becoming a noise spot."

On 13 March 1958, Bowen sent a humorous reply to Bok thanking him for his "exceedingly useful" letter to White:

> The time for decision (or alternatively, to form a sub-committee to advise, or to agree in principle but defer action, or any of the other substitutes for a decision beloved of the Public Servant) is 11 am on Monday the 17th at Head Office. All the boys will be going down and they will have an excellent opportunity of showing their unanimity to the Executive.

The plans for the 17 March 1958 conference at CSIRO Headquarters in Melbourne were under way. On 13 March , Bowen sent Guy Gresford a suggested agenda for the Monday 17 March

[33] NAAC3830 A1/11/1/5A Part 2. Bok also told Bowen about a conversation with Paul Wild at RP. Paul had been offered a professorship at Cornell in the US: "[I]t does seem as though he is being made so favourable an offer that it will be difficult for him to refuse accepting it. Australian astronomy will miss Paul Wild very much." Paul Wild did not accept the offer, staying in Australia to complete the Culgoora Radioheliograph in 1967. (See Frater, R. H., Goss, W. M., & Wendt, H. W. (2017). *Four Pillars of Radio Astronomy: Mills, Christiansen, Wild, Bracewell*. Springer, p. 108)

[34] A hill at elevation 843 m in the NE suburbs of Canberra.

conference between the five RP staff (Wild, Christiansen, McCready, Mills and Kerr) and the CSIRO Executive (Clunies Ross, White and possibly Bastow): (1) Technical requirements of the site, presented by Mills, (2) Non-technical and administrative requirements of the site, Wild, (3) Overseas solutions, Kerr, (4) Physical description of sites examined, McCready, (5) Advantages and disadvantages of three sites, Christiansen and (6) Summing up, Wild.[35]

For the conference three of the participants (Wild, Christiansen and Mills) prepared "Report on the Site Requirements for the GRT"[36], 12 March 1958. (Bok had seen a draft on 6 March during his visit to Sydney.) The three possible sites were discussed in detail: Parkes, Cliffvale and Hoskinstown:

> The siting of the proposed GRT must be considered in relation to the entire radio astronomy programme of which it will form a part, albeit the most important part. It is therefore desirable to keep in mind the other aspects of the programme [including high frequency millimetre radio astronomy with a precision dish, low frequency galactic and extragalactic observations, solar research at metre and centimetre wavelengths].. It is clearly desirable at this stage of development of Australian radio astronomy to provide a site at which a wide variety of investigations can be conducted.

The trio of authors (consisting of three of the four future leaders of Australian radio astronomy, Mills, Christiansen and Wild) was thinking of the future, with a possible structure of a field station that might include a new solar instrument and perhaps a Super-Cross. Their recounting of the past successes of RP since 1945 was prescient:

> Our progress in radio astronomy has, in the past, been very closely linked with the application of advanced radio techniques and the available facilities for rapid engineering construction. The location of the Laboratory in Sydney has had great advantages for both these requirements and has been responsible in part for our success. There is every reason to suppose that, in the future, even more emphasis will be placed on these technical necessities... It is therefore considered that the success of the future programme would be prejudiced if the headquarters of the radio astronomy group were removed from the vicinity of Sydney. Since this requirement conflicts with the necessity for a low level of interference on the actual observing site or sites, it appears that our present system of centralized headquarters and distant field stations is the best suited for our needs. We will therefore assume that the radio astronomy group

[35] Wild's key presentation at the conclusion of the meeting indicates that Bowen and White depended on Wild to provide a fair and considered conclusion to the vexing process of the GRT site decision.
[36] NAA, C3830, A1/3/11/5A, Part 2.

will be located in the environs of Sydney [in fact Epping in January 1968, a delay of a decade] and examine the suitability of various possible sites on this basis.

Mills, Christiansen and Wild pointed out that their proposal was in conflict with an earlier suggestion that the entire radio astronomy group as well as the new radio telescope would move to Canberra: "The only point in its favour [the move to Canberra], [was] an improved liaison with the Mt Stromlo Observatory and the possibility of a moderately good site for the telescope within 30 miles of the [proposed] group headquarters [at Mt. Stromlo]." There was no reason to consider these advantages to "compensate for the severe disadvantages of the move from Sydney". A major motivation (which was admitted) was the antipathy of group members and their families of a move from Sydney to Canberra.

Another concern was radio frequency interference. The GRT was to be a large structure at a height of over 60 m; a location near Sydney was not at all optimum. Thus a site more distant from a large population area was desirable. The proposers placed an upper limit of about 400 km from Sydney, a day's drive.

The report next considered the interference problem. In the light of modern considerations, this discussion is flawed. The proposal was based on the assumption that **confusion** would be the primary source of uncertainty (the fluctuations in the output of the radio telescope) and not receiver noise. "… [F]or the majority of the programmes in which the radio telescope will be involved, a conservative upper limit to the interference level may be based on the **resolution** of the aerial rather than the sensitivity of associated receivers. Such a limit is useful as it is independent of advances in receiver techniques. This will therefore be treated before dealing with practical receivers." [37]

The confusion limit was only appropriate at low frequencies for the GRT (less than 600 MHz) with the GRT in continuum mode of observing. For continuum observations at cm wavelengths, fluctuations due to receiver noise were the dominant factor. In addition, the report assumed that the probable chief source of RFI (radio frequency interference) was to be ignition from engines. Based on this mode of interference, if the real radio astronomy signals were to be ten times the fluctuations, the RFI would need to be less than 0.5 K antenna temperature. The experience in the post 1961 era found that the major sources of RFI were aircraft radars at fixed frequencies, terrestrial radio stations at discrete frequencies, and far in the future, satellite CW (fixed frequency) communications. [38]

[37] Likely added by Mills.

[38] The report did mention: "[A]t metre wavelengths, transmitter interference will be the dominant factor."

The susceptibility of the GRT to RFI was also dependent on whether the observations were line observations (at a single frequency or a range of frequencies as multi-channel receivers were used) or continuum (over a much larger bandwidth). There was also a prescient suggestion that was to be relevant in the modern era: "[O]ne may conceive of an experiment in which cosmological information is derived from the statistics of variability of the background spectra in various regions, and this could require a substantially lower interference level… The study of galactic HI line radiation at high [galactic] latitudes… may usefully employ a sensitivity higher than that dictated by the resolution limit, and need … a lower interference level."

In spite of the misguided claim that the resolution of the GRT at a certain wavelength would determine the sensitivity, the authors did consider that at the HI line of 21 cm (1420 MHz), very low system temperatures would be possible with maser receivers, which were newly available as test installations in 1958. With T_{sys} of about 10 K, it was hoped that a remarkable sensitivity for line observations would be possible. In fact parametric amplifiers and later low noise transistor receivers would become common at the GRT. This increased sensitivity from the receivers meant that the RFI requirement was reduced to about 0.05 K. Thus the report suggested that the RFI levels at, say, 1 GHz would need to be in the range 0.05 to 0.5 K.

Other factors, in addition to low levels of RFI, were required. Pawsey in his July 1957 report Chapter 27 and NRAO ONLINE 43) had summarised additional factors: use of interferometers with baselines of at least one mile or even 10 miles, accessibility of the site, lack of strong winds and ice and snow and excellent soil conditions.

Four sites were evaluated in some detail:

(1) Cliffvale in the Nepean Valley near Camden, 62 km from Sydney University: This was an alluvial flat area, 60 m above sea level. The total area of the property was 180 hectares, but only 16 hectares were to be purchased. The site was shielded by hills 140 m in height. "Distances of several miles of "rolling" country are available for interferometry." Historical "flooding occurred in the late 19th century. The driving time to the Sydney University Lab was about 90 min. In addition the site was only about 30 km from the existing RP site at Fleurs. A major risk for the site was the concern of constructing a stable foundation due to the absence of bed rock within 50-100 m of the surface. A major concern was raised: "A calculated risk would have to be taken that future revolutionary technical developments should not seriously lower the level of tolerable interference, or that future individual expansion in the area should not raise the actual level." In addition, RFI from aircraft from a nearby airport at a distance of about 6 km had been detected.

(2) Near Putty (off the Windsor-Singleton road 150 km from Sydney University): This was a remote site, "convenience and accessibility are both well below the Cliffvale site". This location would only be considered if Cliffvale were to be eliminated due to interference or to the expense of a more distant site (e.g. Cowra or Parkes).

(3) Canberra: Mills, Christiansen and Wild had considered the Hoskinstown site (40 km east of Canberra) as an outstation of the Sydney headquarters ("from the viewpoint of suitability for operation from Sydney"). Interferometry over 1.5 to 2.5 km was possible. The main concern was possible RFI from TV transmitters in Canberra, e.g. Black Mountain. "A definite risk would have to be taken about future transmitters close to Canberra." The description of the weather was not encouraging: "The plain is subject to high winds and is probably bleak in winter." Of course Mills and colleagues did construct the Molonglo Radio Observatory (408 MHz), the Super-Cross at this location in 1963-1967.

(4) Cowra and Parkes: "The region west of Sydney immediately past the dividing range appears to be the closest and most accessible in which the conditions approach the ideal for a radio telescope site, and at which it is possible to make the best use of the advantage to be obtained for radio astronomy in Australia." A vast area near the towns of Yass, Cowra, Forbes, Parkes and Wellington (all about 400 km from Sydney at roughly 300 metres above sea level) were investigated. Two finalists were chosen, one 20 km north of Parkes and the other 20 km from Cowra. Both sites consisted of some km of flat land. The Parkes site had intervening hills between the site and the town. "A further point in its favour is the enthusiastic attitude of the local authorities." (This included the Mayor A.C. Moon, later to be portrayed in the movie "The Dish", the Rob Sitch film of 2000.) The conclusion is striking: "We regard the Parkes site as the nearest to the ideal which is likely to be found, taking into account factors of accessibility as well as electrical requirements. There is, however, one disadvantage of such a distant site; we will have to operate the instrument on a limited budget and the extra administrative costs involved may jeopardize other aspects of the radio astronomy programme." Clearly the authors (Mills, Christiansen and Wild) were apprehensive about the impact on their own aspirations for future projects.[39]

[39] These concerns were a harbinger of concerns that would play a role in the CSIRO breakup up of 1960-1961 as Christiansen, Mills and Pawsey were to leave RPL.

The summary provided a recommendation with Parkes as the obvious first choice:

> From a technical and scientific point of view we regard the Parkes and Cowra sites as the nearest to Sydney which are likely to be completely suitable. If it is found that the administrative expenses in running such a remote site are not so high as to preclude radio astronomy investigations unconnected with the GRT, we would strongly recommend the site at Parkes as the first choice. Alternatively, if it is decided, as a matter of policy, that such investigations will be dropped, and all efforts concentrated on the GRT and associated instruments, we would also strongly recommend the Parkes site.

However, the authors hedged their bets:

> If, on the other hand, it can be shown that a very [their emphasis] substantial monetary saving would be affected with the telescope sited at Cliffvale, and if the survival of our present solar and metre wavelength programmes depends on this saving, the risk in adopting this site [Cliffvale] (subject to the precautions noted earlier) would be worth accepting as reasonable. [However, a] meeting of the Radio Astronomy group expressed themselves generally in favour of a remote site such as Parkes or Cowra.

With this statement, the group here seemed to hedge their bets, as they were concerned that the GRT costs would impact their own aspirations for their own projects (such as the Super - Cross and the Radioheliograph).

Fortunately for us, two independent views of the site selection process of March 1958 are available. Frank Kerr was interviewed by W.T. Sullivan, III, on 3 October 1971 during a car trip from Charlottesville, Virginia to Green Bank, West Virginia. A major topic was the site survey activities of 1958. Kerr said in the first account[40]:

> So, at least about 1958 there was great activity in trying to decide the site [of the GRT]. This perhaps started in 1957, but it really came to a pitch in 1958. And the principle site hunter was Lindsay McCready… in the early stages the hope was to try and get it somewhere on the coastal plains somewhat closer to Sydney… he started off hunting around for possible sites within a hundred miles of Sydney on the coastal plain.There were two or three slightly possible sites, but it was realised eventually that these were all risky, that there was too much [industrial] development going on…. So sometime in

[40] Transcription of interview provided by Sullivan, Also NRAO Archives. Papers of Woodruff T. Sullivan III: Tape Series. https://www.nrao.edu/archives/Sullivan/sullivan_interviewee_kerr.shtml

> 1958 we decided to move across the mountains and find something on the other side of the mountains. Three or four of us [Kerr, Mills, Christiansen and McCready?- perhaps Wild also] went around in a group and we found several possible sites. There was a site near Cowra which looked good, [located] beside the Macquarie River and the site near Parkes we chose, not the present site but one slightly closer to the town. And the Cowra one was eventually given up because it looked as though a company that was interested in canning peas [was to be built here] and it looked unsafe.[41] Also, too, the Cowra town council was not especially interested in us. On the other hand the Parkes people could see exactly what this thing would do for Parkes, and they fell over backwards helping to offer us all sorts of assistance with roads and so on. So it looked a much more friendly atmosphere there. [Bowen] was quite taken with [the site near Parkes]… But then we decided to go look a bit farther. We started driving northwards from the site we had chosen as the first one, and three-four miles farther north we found an even better site. So on that day we decided to go there… a greater area of flat ground and somewhat more isolated, more distant from Parkes… [T]he idea of flat ground was always very important in site selection. This is because of the great interest in Crosses and other sorts of arrays and so as a compromise with the people who had been so interested in arrays [Pawsey, Mills, Christiansen and Wild] it was always stated that the site must be something with a quite large area of flat ground…., so that an array could be built centred on the Parkes dish … So we chose the site as a very likely one and on that day started making inquiries who owned the place. It turned out to be somebody called Australia James Helm [known as Australia "Austie" Helm].[42]

Paul Wild augmented the story of the site selection in his talk at the John G. Bolton Memorial Symposium on 10 December 1993[43], the second account:

> E. G. Bowen was determined to locate [the GRT] on the Nepean River near Camden. It would have been a very beautiful, but very noisy site, and most people were resigned to having the telescope there. But I argued that it should go "over the mountains". Taffy [Bowen] was good enough to arrange a meeting of radio astronomers [the meeting of 17 March 1958] to discuss the matter (to his credit he did not attend himself), with the result that a team of people, an unlikely team consisting of B.Y. Mills (Bernie) , W.N. (Chris) Christiansen, and me [Wild] set out to look for an alternative site, and we

[41] Pawsey's letter to Bowen from 23 February 1958 implies that RPL was already considering a possible GRT site in Cowra in 1957. Kerr's report may well refer to a subsequent visit to this area in 1958.
[42] His name (Australia Helm) is based on his birthday, a special wartime Australia Day in July 1915, a fund raising event for troops in the WWI battle at Gallipoli. See NRAO ONLINE 48 and Chapter 29,
[43] *Australian Journal of Physics*, 1994, vol. 47, "Pioneering a New Astronomy", editors Goddard and Haynes. "Some Reminiscences of J.G. Bolton" by J.P. Wild, page 497.

> finished up at Cowra.[44] We were going to recommend Cowra but Chris had second thoughts, and said he would like to push on a little further [sic]- and he found this magnificent site near Parkes. So it was really Chris's discovery. It was left to Kevin Sheridan and, Frank Gardiner and me, with the aid of a low-flying aircraft, to do some tests to make sure that the site did not suffer from interference from industrial noise from the town of Parkes itself.

These two first hand recollections confirm Christiansen's major role in finding the Parkes site, an ironic event given Chris's antipathy to the GRT project. In addition, Kerr's interview with Sullivan provides an invaluable confirmation of the sequence of events in 1957-58.

The question of the precise locating of the Parkes Telescope has been controversial. In their book *Four Pillars of Radio Astronomy, Mills, Christiansen, Wild, Bracewell*, (2017) Frater, Goss and Frater have discussed this question on pages 42 and 44 in the Mills chapter. Bowen did stage a later placement of a peg after the initial peg location by Mills and colleagues in March 1958; however, the date of the staged ceremony was in mid to late 1959, not September 1961 as Frater et al have suggested. Details of this complex story are presented in NRAO ONLINE 48. This text is based on a collaboration with John Sarkissian.

The summit conference in Melbourne, 17 March 1958

The result of the 17 March 1958 meeting between the RP staff and the CSIRO Executive was a foregone conclusion. Bowen was quite pleased as he wrote to Pawsey on 20 March[45]:

> There were some ecstasies of indecision about the site for the telescope, but Christiansen, Mills, Wild, Kerr and McCready did some hectic running around and finally came out decidedly and unanimously in favour of Parkes. I think this is an excellent choice and it was agreed to by the Executive last Monday [17 March], practically without a fight. The boys are writing to give you more details. Incidentally Bok is on our side, is heartily in favour of Parkes and is now focusing his attention on the region north-west of Parkes for his own main observing station. McCready is now negotiating purchase with the owners and the city fathers and should be possible to start test borings in one or two weeks.

On the same day (20 March 1958), Bowen wrote an up-beat letter[46] to Gilbert Roberts at FFP:

> Since your departure we have changed our minds about… the question of site. When you were here [January-February 1958] you were quick to sense a spirit of uncertainty

[44] There was no mention of the role of Lindsay McCready.
[45] NAA, C3830 , F1/4/PAW5.
[46] NAA, C3830, A1/3/11/1, Part 10.

> on this whole question. Soon after you left, our radio astronomers went through a period of agonising re-appraisal and they have now decided finally, unanimously and unalterably that the site should be over the mountains… near Parkes which is accessible from Sydney by road, rail and air. The outstanding reason… is to take advantage of the fact that here in Australia sites can be found which have a far lower… noise level than any which are likely to be found in Europe or the USA and it would be foolish of us in a project of this magnitude not to make the fullest possible use of this natural advantage.[47]

Roberts was also pleased (26 March 1958 letter from Roberts to Bowen) with the improved prospects of the foundations at Parkes as compared to Cliffvale: "Certainly the absence of flooding would be an advantage, and I was never altogether happy about the prospect of the telescope looking like a Dutch windmill in the flooded countryside. Also the necessity of keeping the ground floor above flood level would inevitably have added something to the expense."[48]

Bowen immediately (26 March 1958) informed Martin Grace (Secretary, Finance and Supplies of CSIRO)[49] in Melbourne about the consequences of the newly selected site at Parkes for the expected costs of the GRT: "It is only within the last month or so that they [the radio astronomy group at RPL] have really got down to the job of [site selection]. And in the light of current developments that will almost certainly produce receivers some 10 times as sensitive as the best now available, reached a unanimous decision that there is no site good enough within easy distance of Sydney." Now more accommodation would be necessary at Parkes since this was to be a field station that could not be staffed on a daily basis by the personnel from the lab in Sydney. Almost at the same time, a detailed plan for the Parkes site had been sent to the CSIRO

[47] NAA C3830 A1/11/1/5A Part 1. Bowen also wrote Minnett on 20 March 1958, who had just returned to London, FFP. ".. [A]fter some hectic running around the countryside, the radio astronomers have finally decided on Parkes as the ideal site for the telescope… [The new site] seems to be a location which will have as low a noise level as anywhere in Australia. I have just written to Roberts telling him of the change and I hope it does not affect his plans or ideas in any way. At least, when he was here, he insisted that there was no difference between Sydney and Canberra as far as erection of the telescope was concerned, so presumably there is also no difference between Sydney and Parkes."

[48] Roberts had just been in Pasadena, meeting Bolton and Bruce Rule for discussions about the design of the new 90 foot antennas for the Owens Valley Radio Observatory of Caltech. Roberts had visited AUI in New York and saw the plans for the 140 foot equatorial radio telescope. "In New York I [Roberts] saw the AUI people who have lost contact with reality in their design. They told me the weight of the instrument is now 4,000 tons… I suppose one day they will find solutions to all these problems, and if they can stop creating new ones, the telescope will eventually be built. At the moment that time looks to be pretty far off." The opening of the 140 foot was 13 October 1965, seven years later.

[49] NAA, C3830, A1/3/11/3, Part 4.

by Bowen, consisting of residences for the engineer in charge of the site and accommodation for visiting staff members at the "Parkes Radio Astronomy Observatory".

Pawsey wrote back to Bowen from Caltech on 26 March 1958 ("Dear Taffy") with the announcement of his arrival date in Sydney, 25 April. He reacted to Bowen's letter of 20 March with news of the FFP negotiations and especially the news of the site selection. "I was very glad to get your letter of March 20 saying all controversial issues about the GRT have been solved, or should I say decided on. [The site] looks like a superbly noise free area. It is a pity we could not combine this with locating at our backdoor but I guess we live in the wrong city**.** I hope Bart [Bok] does decide to set up in a field observatory in the same section of the country."

Finally during the months after the 17 March 1958 decisions made in Melbourne, Bowen informed other GRT stake holders about the site decision of 17 March 1958. For example, on 23 May Bowen informed Stephan Stackpole, the Executive Associate for the British Dominions and Colonial Program of the Carnegie Corporation of New York, the first external GRT donor from 1954, of the encouraging news of 1958: (1) The design study of FFP was completed in late 1957 and the final design of the telescope was expected in mid-1958. Bowen then presented the estimate of an overly optimistic prediction that bids would be be received in August or September 1958. This was to lead contracts being placed in September 1958 with a start of construction before the end of 1958. Then the construction period would last f two years with scientific research with the telescope to begin in early 1961. (2) A summary of the site surveys was presented with the rationale of the choice for Parkes, where 53 hectares of land were to be purchased. The description of the location was grandiose: "It is in attractive parklands surrounded by low foothills and eminently suited to a wide variety of activities in radio astronomy. The noise level is exceptionally low, and legal steps will be taken to protect the area from possible encroachment by sources of electrical noise in the future."

By 30 June 1958, Bowen sent a press release to the Prime Minister (Menzies) for possible release in the House of Representatives in Canberra. A major part of the announcement was the description of the new site at Parkes. A public news release was also provided on 14 August 1958. An important aspect of this statement read: "The optical astronomers at Mount Stromlo already work in close cooperation with the radio astronomers, and the facilities of the GRT will be available to any astronomer, Australian or overseas, who has a special problem which can be solved with the aid of the new instrument." The latter is a clear expression of an "open skies" policy. Details of the press releases are discussed in Additional Note 2. However, there is no evidence that these texts were in fact distributed to the Australian press; no press reports have been located for the period after August 1958.

By end of March 1958, contact had been made by CSIRO with Austie Helm of the property "Kildare", Goobang, north of Parkes. On 21 March 1958, Lindsay McCready visited Helm and his

wife.[50] Helm had agreed to the purchase of about 52 hectares (128 acres) for a price of £A 100 per hectare. Helm would retain the grazing and cropping rights for this property, on a lease basis. McCready sent Helm a photo of their meeting on Friday 21 March ("[The photo], which I believe will turn out to be an historic one.")

At the same time, RP was in contact with the local Goobang Council with a request to close a few "little used roads" near the GRT site. In addition, Wild, Christiansen, Mills and McCready met with Postmaster General (PMG) engineers on 25 March1958 to discuss local frequency protection. The radio astronomy committee then gave Christiansen and Kerr the task of formulating a proposal to the CCIR (International Radio Consultative Committee) for additional frequency protection. Christiansen prepared a four page memo for White, summarising his presentation to the CCIR meeting in Melbourne on 21 April 1958. Chris summarised the RFI levels presented in the Mills, Christiansen and Wild report of 12 March. The main consideration was:

> [T]he possibility of radio transmitters operating in the range 300-3000 Mc/s or having strong harmonics in this range, being erected close to the site, during future years. For this reason we are requesting the various authorities responsible for radio transmissions for assistance in this matter.

A significant interaction with the Minister for the CSIRO, R.G. Casey, occurred starting in late June 1958.[51] White had reported to Casey about the newly chosen site at Parkes. The Minister had numerous questions such as: What about commercial radio stations in Parkes? Had the town of Griffith been considered since this had a "good airfield"? (Casey was an avid pilot.) CSIRO was prepared to give him a detailed briefing. After a series of communications, Pawsey brought to the CSIRO office in Melbourne a written summary for the Minister on 23 June 1958. Also he brought a draft public announcement for the press regarding the selection of Parkes as the future home of the GRT. Three days after Pawsey's visit to Melbourne, White wrote Bowen (26 June 1958) with a number of detailed questions posed by Casey. Casey's decisive question was: "The area that is proposed to acquire seems to me to be very small. Don't we need the protection of a bigger site?" White added … "The Minister... wanted to know whether we really should not buy a much bigger site, say, 500 acres [200 hectares]." Bowen replied on 11 July 1958 that RP was aware of the limited size of the site and would try to increase the acreage at a later date. Then on 24 July 1958, Bowen had good news. McCready visited Austie Helm on 23 July, who agreed to a sale of 166 hectares, a factor of three larger than the original plan. Helm

[50] NAA, C3830, A1/11/3/5A, Part 2. Letters to Helm from Bowen and Bowen on 26 March 1958.
[51] *Ibid*

then insisted on a 15 year lease for grazing purposes. Without Casey's pressure, this important additional sale would likely not have occurred.[52].

On 5 September 1958, McCready wrote Helm that on 10-11 September: "We hope to install gear for recording windspeed and direction... Two of our chaps will erect the [aluminium alloy] poles on Thursday and Friday. I could also be available during the course of other duties to help if necessary." Fig 5 in NRAO ONLINE 48 shows Pawsey's possible participation at this event at the Parkes site in September 1958.

Escalating Conflict with FFP – 1958

The source of major problems with FFP that developed in 1958 to early 1959 had an origin in agreements made earlier by FFP in 1958 (Robertson, 1992, has provided a thorough account of these activities.) In 1956, Roberts approached a number of firms in the UK, soliciting participation in the GRT project. These firms were, of course, heavily committed to defence projects with lucrative, long term contracts with the defence establishment in the UK, not "one-off" scientific projects with major start-up expenses and no long-term follow-up. Robertson has provided details (1992, p. 155):

> In view of this disappointing response in 1956[53], Freeman-Fox [in 1958] felt there would be little to be gained by throwing the project open to a competitive tender and, instead, decided to divide the project into three contracts and make its own selection of the contractors it believed best suited to the task. Early in 1958 these firms were chosen: Metropolitan-Vickers (Manchester) to act as the main contractor; Grubb Parsons (Newcastle) to develop the master equatorial system; and Sir William Arrols [*sic* Sir William Arrol a Scottish civil engineer and bridge builder, 1839 to 1913] and Partners (Glasgow) to fabricate the heavy structural components and to construct the telescope

[52] When McCready had first approached Helm earlier in 1958, the farmer (Austie Helm) was only interested in a sale of 50 acres (20 hectares). Bowen wrote on 24 July to CSIRO: "In view of the attitude of the Minister we have taken up again with Helm the question of acquiring what would be the most useful acreage…There is no question at all of the desirability of acquiring this larger area… ultimately required for subsidiary projects associated with the GRT." Casey had also been concerned about the wind at Parkes. On 26 June 1958, White reported that the Minister asked: "I thought that we were seeking a site that had some protection from wind? This Parkes site would seem to be 'made' for wind from the West." Bowen reported on 11 July 1958 that Parkes showed more moderate winds than either Camden or Canberra.

[53] FFP had approached a number of British firms who might have been able to contribute to the construction of the GBT. These firms expressed little interest in a project "involving so many untried engineering features and, not least, one which promised little financial reward". (Robertson, P. (1992). "Beyond Southern Skies: Radio Astronomy and the Parkes Telescope." Cambridge University Press. p 154)

> at a site halfway around the globe. Metrovick and Grubb Parsons had been closely involved in the design study during 1957, so both firms seemed a logical choice.

Given the complexity of these arrangements (including possible overlapping or even contradictory responsibilities), it was hardly a surprise that major conflicts arose between the Australians and FFP and even more dangerous to the project, conflicts between FFP and the firms. Too many parties were major players; from the archive record it is not clear if RP concurred with the initial initiatives of FFP in 1956 and again in 1958. In the end, RP and especially Bowen had to intervene to advance the project in finding a contractor in 1959, as well as to begin construction (see Chapter 29 and NRAO ONLINE 45).

The first sign of trouble came in a communication from Minnett, after he had been back at the London office of FFP for slightly less than two months. On 14 May 1958[54], Harry reported to Bowen that the contract issues were becoming chaotic. He wrote:

> You will remember that when in Sydney, Roberts received a telegram to the effect that Metrovick had agreed to be main contractor for the supply of all controls and drives, with Grubb Parsons and Arrols [sic] as sub-contractors. Metrovick was to carry out the trial erection of the necessary structure in the UK and AEI-Australia (Associated Electrical Industries, the holding company formed by the merger of of Metrovick and British Thompson-Houston was to undertake site erection of the steel structure up to and including the hub, together with the installation of all controls, drives, cabling, instruments and accessories. Metrovick had also agreed to accept responsibility for the overall specified control performance on site but not, of course, the dimensional accuracy of the dish, which would be the concern of an independent local [Australian] contractor.

The complex arrangements fell apart on 6 May 1958 [possibly the meeting was a week later, 13 May], when a new sales manager (Barton) from Metrovick disagreed with the previous agreement made with FFP. He asserted that the Metrovick organisation would only assume responsibility for a project if its share was at least 70 per cent of the total. Since this threshold was not satisfied, Metrovick would not assume liability for the two major subcontractors. Thus the contract was unacceptable. Barton would consider a contract in which “Grubb Parsons and Arrols each sub-contracted to assume full responsibility for producing their components to an agreed specification.” Metrovick would produce the rest of the drive system, also to specification. The erection work by AEI -Australia would have to be the subject of a separate contract. AEI would have to accept responsibility for this part of the work. In this proposal,

[54] NAA C3830 A1/3/10/11, Part 3

there would therefore be four contractors and two sub-contractors. Since Barton was "in an aggressive, rather unpleasant mood" the situation was at an impasse.

Based on this unpleasant news, on 26 May 1958 Bowen expressed misgivings to White about Metovick[55]: "[I]t is the old hot and cold treatment beloved of the larger British firms. At some stage they always seem able to produce a bad-tempered monster who knows nothing about anything and who makes a nuisance of himself. It is usually the prelude to the price going up." Bowen had told Harry Minnett (in London) to discuss with Roberts whether an intervention by the CSIRO Minister, Casey, would be helpful.[56] Immediately on 27 May 1958, Roberts expressed his frustration with Metrovick's slow progress in estimating the cost of the telescope in a letter to Bowen. A more serious problem was "the commercial people [of Metrovick] are not at all keen on taking on what appears to them a disproportionate amount of the responsibility but I hope we can sort this out… The biggest difficulty may be to get them to take responsibility for the site erection work by [Metrovick]." Clearly delineation of the site erection duties between Metrovick and Sir William Arrol and Company was a messy negotiation. Roberts ended the letter with a bizarre rejoinder: "If you can think of any other difficulties in the project please **do not bother** (our emphasis) to write about them, because I am quite sure they have already been raised by some party or other here." Bowen, of course, ignored this advice in the following months.

A first-hand update on the situation at FFP and the situation with the British firms was provide by J.L. Pawsey who was on another overseas trip from 6 July to 3 September 1958 (Chapter 28), beginning with a visit to London on 8 July. Pawsey visited FFP and Harry Minnett starting on 9 July; after 2 ½ days he had a "clear picture of the developments on the GRT."[57] His report to Bowen (11 July) was generally optimistic, with an emphasis on a cautious approach to all problems. On some of the issues, Pawsey was clearly sceptical of the value of the information provided by FFP. Pawsey reported that FFP discouraged a direct approach by the Australian government (via Casey) to Metrovick. Ironically, Casey did visit Lord Chandros (Chairman of Metrovick) on 4 September 1958 with an expression of the Australian misgivings concerning the delays at Metrovick.

Pawsey described the design work at FFP of the "half-dozen engineers working on our jobs". The top priority for re-design in mid-1958 was the drive system, gear boxes etc. The second priority was the dish structure, prompted by comments from the Sydney conference of January

[55] NAA C3830 A1/3/11/1, Part 10
[56] *Ibid.* The contact would be with Casey's personal friend Captain Oliver Lyttelton, Lord Chandos, who was chairman of Metrovick from 1945-1951 and then 1954-1963. Metrovick, Metropolitan-Vickers – later Associated Electrical Industries was located in Trafford Park, Manchester. The factory was a major heavy engineering facility for most of the 20th century.
[57] NAA C3830 A1/3/11/1, Part 11, 11 July 1958

1958. The major concern was the proposed Metrovick contract: "…[T]here is known to be considerable diversion of opinion within the company itself and Roberts expresses himself as quite optimistic about settling the contract in principle within the next weeks." (The delay was to be many months, extending into 1959.) Pawsey reported that the senior management of FFP had left "the GRT in Roberts's hands". Pawsey said they would have to "wait in patience for awhile until we see how the Metrovick situation works out and the essentials of the new design are clear. Just at the moment one sees a lack of progress. This situation could change overnight."[58]

A few weeks later (1 August 1958), Roberts wrote a discouraging letter to Bowen with reports of continued problems with Metrovick[59]:

> ...[O]ur negotiations with [Metrovick] have not gone as smoothly as I had hoped. The commercial people [are] reluctant to commit themselves to lots of responsibility for work which it seemed to them as not entirely in their control, and although they were not unwilling to take on the main contract, it appeared that they were trying to hedge the guarantee of pointing accuracy…. [Roberts was concerned that Metrovick had overdesigned certain aspects of the servo system, the gear boxes in particular… the relation with Arrol was still unclear] ...[Arrol] would **probably** [our emphasis] make the heavy mechanical work as well as the structure….

Roberts ended with some forced humour and a distant threat:

> At the time of writing the dish diameter remains at 210 feet and I trust it will not be necessary to reduce it still further. Much depends, however on the avoidance of any further frills for which we have not so far allowed. I think you agreed that the basic instrument should consist only of the bare essentials, leaving the scientific refinements, like the Staff Recreation Rooms and Ornamental Gardens, to be added later. I am

[58] NAA C3830 Z1/14/A, Part 1. 24 July 1958. Minnett wrote Bowen with a description of a revealing visit to Jodrell Bank with Pawsey for two days during the week of 14 July 1958. The letter was to be shown only to Christiansen, Kerr, Wild, McCready and Pawsey (on his return). The performance of the 250 foot telescope was quite discouraging, with low gain at 20 cm and severe pointing problems. Large deformation of the dish surface had appeared with use. "Fairly long circumferential ridges or steps about 2 inches high have appeared here and there in the welded steel surface and are said to be due to twisting of the supporting purlins." It was difficult to obtain quantitative information on the shape of the dish. At 20 cm the beam was only 15 arc min with 25 per cent side lobes at 45 arc min from the beam centre. The gain at 20 cm was only equivalent to a 100 foot antenna due to the surface errors. The pointing errors were in the range 2 to 5 arc min. "On the whole the drive and control system seems to be working as well as the specification required and is probably capable of improvement. The real limitation to the operation of the telescope at high-frequencies [1.4GHz] is the dish shape and there the possibilities for improvement are not so clear."

[59] NAA C3830 A1/3/11/1, Part 11

> desperately anxious to get the new scheme settled by the end of September [1958], so that I can go away for a short holiday, [on] my round the globe to see you in Sydney.

Three months later, Bowen was completely exasperated with the status at FFP. A letter from Harry Minnett reinforced this opinion. In early November 1958, Harry's letter arrived, "which sheds a depressing light on the status of the GRT project at FFP".[60]

On 7 November 1958, Bowen held a meeting with Pawsey, Christiansen, Wild, Kerr, McCready and Higgs to plan a course of action based on the reports from London.[61] Bowen began with an expression of frustration with FFP: "[I have] serious concern at the continuing failure to meet promised deadlines." The straw that broke the camel's back in late 1958 was the slipping deadline for the arrangements for the drive and control gear (from Metrovick) from August-September 1958 to October 1958 and then to February 1959. (Later in the year, Bowen was to blame the delay at Metrovick on lack of pressure from FFP.) Bowen's proposal to break the log-jam was to (1) communicate with FFP immediately with an expression of dissatisfaction about the current status and (2) for Bowen to visit the UK to "find why finalisation was being delayed [and] to endeavour to accelerate matters and obtain reliable figures on possible costs and delivery times…" Bowen then made a serious threat (7 November 1958, Minutes of GRT Committee meeting):

> Dr Bowen then pointed out that it has been almost three years since negotiations with FFP began, but not a single item of hardware has yet been obtained, and not a single contract for the supply of equipment has yet been entered into. He felt we should have little hesitation in cancelling the present arrangements with FFP – and there were no contractual or other reason why this could not be done- if we were unable to obtain satisfactory answers on cost and delivery dates in the very near future. [The expected future use of low noise masers and parametric amplifiers] would raise the sensitivity attainable with smaller dishes and thus, to some extent, offset the unique advantages of a very large aerial.[62]

Bowen then suggested several possibilities for smaller antennas: (1) acquire copies of the 90 foot (27 m) Caltech –Bolton dishes or (2) a copy of a variation of a 36 m (118 foot) East German dish (transit only) which would be converted to alt-azimuth via negotiations with Otto

60 NAA C3830 A1/3/11/1, Part 11. Bowen to White, 7 November 1958.

[61] Ibid, minutes of GRT Committee meeting 7 November 1958. The letter showed Bowen at his best as he reacted effectively to the mismanagement of the project shown by FFP. Pawsey played a smaller role at this point by trying to placate Minnett in London, in particular his letter to Minnett on 21 November 1958. During this period, Bowen began to lose faith in the impartiality of Minnett. Additional Note 3

[62] Robertson (1992) has a similar quote in a letter from Bowen to White of 7 November 1958, written in a more muted tone.

Hachenberg. In the end, the committee did agree that the FFP design was preferable, but only if available "not much later than the original estimate of 1961."

Bowen reported to White on 7 November 1958 that a serious problem remained: only the drive and control system was being discussed with Metrovick. "No progress of any kind has yet been made on the dish structure [reflector]…." The purpose of Bowen's trip to London was to find out the reasons for the delay, obtain a "first hand estimate of the future timetable and attempt to accelerate it and obtain an independent estimate of costs and delivery dates from Metrovick, Arrol, and Grubb Parsons." Bowen was certain he was unlikely to get enough "accurate" information via correspondence from FFP or even Harry Minnett to be able to make a sensible decision. A face-to-face meeting was required. "If this objective were not achieved, I [think] dramatic action would be needed in relation to [a possible] plan for the GRT…" The direct contact would enable Bowen to make a decisive recommendation for the future.

Also on the same day as the meeting (7 November 1958), Bowen wrote to White [63]with a summary of the current situation with FFP, leading to his imminent departure (13 November 1958) for London via New York . The main purpose of the visit to London was to confront FFP. Bowen: "It appears, therefore, that FFP have again failed to give us realistic estimates of dates… They have also failed to follow up the very significant step forward which the Minister [Casey] made when he clarified the main contract [Metrovick] with Lord Chandos on 4 September [1958]." Bowen summarised all the missed deadlines, which had been settled with Roberts during his January 1958 visit to Sydney. The letter from Minnett (posted 29 October, arriving early November 1958) outlined all the new deadlines for the end of 1958 and early 1959. Bowen expected that all deadlines would be missed.

TAILTWISTER I [64]- Bowen to London 1958

Within six days (on 13 November 1958), Bowen was on his way to London via New York. Just before he left Sydney, Minnett sent an urgent telegram to Bowen, who had just departed. "I consider immediate visit completely premature." Minnett asserted that the main reason for the long and unpredictable delays with the completion of the contracts with Metrovick was the pressure of defence contracts.[65] In addition, Minnett sent a two-page letter[66] to Bowen to

[63] NAA, C3830, A1/3/11/1/, Part 11. In the letter, Bowen mentioned a key date. Roberts left for holiday in Bermuda on 16 October to return to London on about 11 November 1958.
[64]The name Tailtwister was invented in January 1959 by Jack Roderick, Professor of Civil Engineering, Sydney University, to describe Bowen's contentious visits to London and FFP in late 1958 (Tailtwister I) and early 1959 (Tailtwister II)
[65] NAA C3830 A1/3/11/1, Part 11
[66] NAA C3830 A1/13/11/10, Part 3

Sydney (posted 13 November, which arrived some days after Bowen's departure) with an amplification of his pleas for a postponement of the visit:

> On October 29th [1958], I advised you that a visit at the end of the year might be both profitable and necessary. To come now, however, would be premature and might simply waste the opportunity you will have in a couple of months of taking part in and speeding up the final stages of the Metrovick contract. … It is incorrect to think that FFP are very seriously behind schedule. They have in fact done a splendid job and nothing would be achieved by harassing them at this stage…. It does not help therefore to attack FFP about the present rate of progress, since their own work is progressing well… [N]egotiating a detailed Technical Specification for a high-accuracy GRT is a big job and cannot be done in a couple of weeks no matter how hard people work. … In short, I strongly advise you to postpone this trip until early in the new-year [1959], when FFP will have finished the groundwork for the Metrovick contract. Otherwise… you may be able to only confirm for yourself the immense amount of work that has had to be done to bring this contract to within two or three months of completion.

The details of Pawsey's (acting chief during Bowen's absence) involvement with Minnett in November 1958, especially the origin of the "fatherly advice" letter from Pawsey (21 November 1958), urging him not to take sides with FFP opposed to Bowen, are summarised in Additional Note 3.

On arrival in London on 18 November 1958, Bowen went straight to the offices of FFP to begin detailed discussions with Minnett, Roberts and others. Roberts had recently returned from Bermuda and was away visiting other clients. Ralph Freeman was in Auckland for discussions about n FFP's participation in the Auckland Harbour Bridge project; he passed through Sydney on the way to New Zealand and was hosted by Pawsey. In Sydney, Freeman provided few details concerning the GRT problems; clearly Roberts was in charge. Bowen reported to White on 21 November 1958 with initial impressions. He was convinced that the "threat" of his visit had led to "a considerable pulling together of loose ends at FFP", similar to the effect of Minister Casey's earlier visit in September 1958 when "there was similar activity to get all available information in the hands of Metropolitan Vickers [Metrovick] before he actually showed up…. I am quite satisfied that it is an excellent thing I came…" Bowen's worst fears were mainly confirmed ("fractionally better than outlined in my letter of November 7 [from Sydney]"). The disaster with the dish [reflector] was serious: "Roberts nor his engineers are prepared to talk about the dish, and freely admit that they have hardly thought about it the last six months. This is one of the clearest deficiencies at FFP. They are a small outfit [for] the work which they try to do…" Bowen finally met Roberts; Bowen, as well as the junior FFP engineers, did not believe the claimed date of completion of the GRT by January 1961. Clearly the

concerns expressed by Minnett about the ill-timing of Bowen's visit expressed in his 13 November 1958 letter, were not confirmed. Major problems remained.

Bowen (21 November 1958) was again not impressed as he wrote to White

> It is obvious that FFP are a group of very eminent engineers of high calibre, and with a tremendous reputation behind them. It is also clear that they are a bunch of old men who are tired, over-worked and operate almost by an intuitive process. They give no responsibility of any kind to their young engineers. In even the simplest matters, they do not say- "Go out and fix it and make it good". …[Another difficulty] is that no hard and fast time-table appears to exist except clandestinely on rough pieces of paper…. [T]he dates and time in which things might or might not get done are kept in Roberts's head, [if he is absent] nothing seems to be done about it. Harry Minnett has told us of these things in a guarded way, but it sticks out when contact is made at first hand.

Bowen both praised and criticised Minnett in this letter to White (21 November 1958):

> I am satisfied that Harry Minnett has done an absolutely first rate job under difficult conditions. Without him FFP would still be floundering around on the drive and control problems. And there would have been nothing like the progress which in fact has occurred…..[H]e has been wholly responsible for supervising the design of the control system. The very fact that he has been so deeply involved on this problem means that he has not been able to make an outside view and put his finger on some of the weak spots…

In summary, Bowen was quite positive about the FFP design and expected (as it turned out) that there would be no major constructional or operating issues. But he was apprehensive about two major aspects: completion date and the cost estimates made by Roberts. Even though Roberts asserted his cost estimates (£A 560,000) would be realistic when the tenders arrived, Bowen thought "this is hard to believe on the evidence which has so far been presented". It did turn out that Bowen's concerns were justified.

During the first days of December 1958[67], Bowen, Roberts and Minnett arrived back in London (to FFP) after traveling to the north of England and Scotland. Bowen reported in detail to White back in Australia on 2 December 1958. The three colleagues had visited Grubb Parsons at Newcastle, Metrovick at Manchester and Sir William Arrol at Glasgow, Scotland. At Grubb Parsons, Bowen received the "thoroughly depressing picture" of a delivery time of the master equatorial and control desk of 2 ½ years. Sir William Arrol and Company would complete the steel work for the turret and central hub of the aerial in 12-15 months, followed by a three

[67] Ibid, 2 December 1958. Bowen to White, copy to Pawsey.

months' test period in Glasgow. Metrovick, following Grubb Parsons's time scale, would produce the gear boxes and servo system, plus tests at Glasgow in a 2 ½ year period. The estimates of the firms' costs were to be produced by mid-February 1959, a delay of five months compared to the dates given by FFP to RP a few months earlier. Bowen asserted that the lack of pressure from FFP in the period after the return of Roberts from Sydney in February 1958 up to Casey's visit to FFP in September explained the absence of Metrovick activity in the first half of 1958: "I [Bowen] cannot help feeling if I had not made this trip the above dates would have slipped still further into the distance. It seems to require some very specific event, like this visit of mine or a rocket [extreme pressure], to get these people moving." Bowen was also certain that the estimated costs to be provided by Metrovick would provide a "resounding shock". Also the GRT fabrication and tests would only be finished by July 1961, with shipment to Australia in December 1961. The telescope at Parkes would then be completed by July 1962, 1 ½ years later than Roberts had suggested a week earlier in late November.[68]

Before leaving London at the end of the first week of December 1958for New York, Bowen had a summary conference with R.E. Fordham, Senior Partner of FFP. He praised the FFP design[69] . He wrote to Fordham

> … Roberts and his engineers have arrived at an excellent design of [a] radiotelescope and they are to be congratulated on achieving an elegant and economical design. There is every likelihood that the final instrument will have a higher surface accuracy and a far higher pointing accuracy than the only other instrument of comparable size, namely the radiotelescope at Jodrell Bank.

Bowen was quite critical of the slow progress on the GRT and blamed this on insufficient manpower at FFP. The delivery times for the contractors were unacceptable; the final cost of the GRT would likely exceed the available funds. The only feasible solution was not to scale down the size but to raise additional funds. "In conclusion, in view of the important decisions which have to be made in February 1959, I am planning to be in London again at that date. I trust that the project will have made a good deal of progress by that time and that we shall be able to proceed to the structural stage without too many difficulties."[70]

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[68] Ibid. The day after the report was sent to White on 2 December 1958, Bowen traveled to East Berlin to look at the 36 metre dish, Otto Hackenberg.

[69] *Ibid* letter to Fordham 12 December 1958

[70] NAA C3830 A1/3/10/11, Part 3. On 16 December 1958, Minnett sent a 9 page letter to Bowen in Sydney. "As requested this letter contains the information given you on November 18/19th on the history of the design work at FFP, and my view at that time about the probable time table of future work." The letter is a detailed listing of actions and meetings that took place from 21 April to 21 November 1958 at the contractors: Metrovick at Trafford Park and Sheffield, Grubb Parsons, Newcastle-upon-Tyne, Arrolat Glasgow and SKF (the bearing company) at Lutton as well as design work (and

Bowen returned to Australia on 23 December 1958; on the day before Christmas, he sent a long report to Fred White. Bowen was gearing up to begin yet another trip to the US and Europe in the new year, 1959 -"Tailtwister II". The report consisted of a repeat of his frustrations with FFP (e.g. lack of manpower and of the "right sense of urgency"). He did return to his criticism of Harry Minnett: "An unfortunate outcome of this [Minnett's magnificent job as a design engineer] is that Harry now behaves as a FFP employee. He is hurt by suggestions that things are going slowly, makes excuses for it and puts no pressure on FFP to get things going faster." Bowen saved his harshest criticism for Gilbert Roberts: "He is undoubtedly a great engineer, but his idiosyncrasies do not make for the smooth and efficient working of the project. He also has great difficulty in answering a direct question. He infuriates the people at Metrovick. He does not get on at all with Metrovick who after all are going to be the main contractors on the job." Bowen had talked with Bruce Rule at Caltech about the 2 ½ year delivery time of the master equatorial from Grubb Parsons; Rule suggested that they try a German contractor such as Zeiss. (In 1959, Askania of Germany would win the contract to produce the master equatorial the ME.) Bowen also organised for Harry Minnett (letter from Bowen 31 December 1958) to visit the US in early 1959, in search of additional possible contractors for the master equatorial.

By the end of 1958 (11 November), CSIRO recognised a growing challenge regarding the Rockefeller grant from December 1955.[71] The conditions of the grant had stipulated a time limit of three years; by the end of 1958 only US $19,000 out of a total of $250,000 had been spent. Bowen anticipated this problem in a letter to White. Within a week (17 November 1958[72]), Warren Weaver, Vice-President for Physical and Medical Sciences at Rockefeller, had written to Bowen. Weaver indicated that a one year extension on the duration of the grant would be possible, if an application were to be submitted. Fortunately, Bowen was in New York twice, on the way to and from London (15 November and 9 December 1958). Bowen and Weaver likely had a telephone conversation in November; in December, Bowen visited Weaver in person, providing a detailed report on the conflicts with FFP and the prospects for progress. On 5 December 1958 (before Bowen's personal visit, but before the receipt of a detailed letter from

participants) at FFP. The complexity of the process was obvious: "The Metrovick contract includes the hub, turret and counterweight structures, mechanical drive systems, electrical machinery, servo-guidance and the ancillary control and indication system. It comprises about two-thirds of the total cost of the system." The "periodic technical sessions" were held "at the works concerned or in London. Minnett concluded the letter to Bowen: "At the time of our meetings [in November], my view was that the Metrovick contract had been delayed by about three months because of the extensive redesign which had been undertaken in almost complete isolation from Metrovick, and the hesitancy at FFP in settling the contract issue. I have said…. the troubles were now over and that no further delay should accumulate…" His best estimate depended yet again on the cost estimation process at Metrovick and the sub-contractors. He assumed that Metrovick would produce a firm quote in January 1959.

[71] NAA, C3830, A1/3/11/3, Part 4.

[72] *Ibid*

White to Weaver, 19 November), Weaver wrote: “In view of the circumstances a three-year extension of our appropriation seems indicated.” A week later (12 December 1958), Bowen wrote Weaver with a detailed summary of their meeting of 9 December in New York City. A major goal of this letter was to justify the long delay in moving forward with the GRT.

Bowen put the best possible face on a messy situation: “It is clear from my visit to London that for the past twelve months we have been trading time in order to save money. If by spending an extra three months on a design detail it has been possible to save a fair sum of money, FFP have done so. This has proved to be an excellent discipline and has led to a very economical and elegant design. However, if the process is continued too far we may reach the stage of prejudicing at least one of the objectives of the project, namely [the building of a GRT in the south to supplement the Manchester aerial in the north].” Although somewhat disingenuous, the letter did paint an optimistic picture in the face of adversity. Bowen wrote White on 24 December 1958, with more important news about his visit to the Rockefeller Foundation earlier in December[73]:

> As a result of what I told him [Weaver] about delivery dates he immediately took steps to extend our grant for another four years, not one year as he had originally suggested. I also thought it time to forecast that the cost of the telescope would increase by at least 50 per cent. This did not bother him and he gave me a number of hints (which I will not commit to paper) on what we should subsequently do [to provide additional funds].[74]

ADDITIONAL NOTES

ADDITIONAL NOTE 1 Wallis Disaffection with FFP – 1956 and 1957

On 22 January 1958, Bowen wrote[75] to Barnes Wallis with a request for his comments on the FFP design study which had only been completed in November 1957 (see NRAO ONLINE 43).) Wallis was no longer involved with details of the GRT work at FFP. (Details of his growing disaffection with FFP remain uncertain.). Bowen commended Barnes Wallis for the master equatorial concept in the alt-azimuth design, “which of course was one of many suggestions which were originally made by you”. Bowen requested Wallis to “express your views quite freely” on the merits of the FFP study. Wallis wrote back to Bowen on 4 February 1958

[73] NAA, C3830, A1/3/11/1, Part 11.
[74] Bowen had also visited Stackpole of the Carnegie Corporation of New York; although sympathetic to the Australians, they had no extra funds for an additional grant.
[75] NAA, C3830, A1/3/11/1 Part 10.

(including a telegram that preceded the letter) pointing out in a testy reply that he had only received the report on 31 December 1957; thus for him to follow Bowen's request for a reply by early February was difficult[76]: "It requires just as careful study on my part as it does on yours. When you realise that I am working six days in the week for Vickers-Armstrong, you will understand that the time allowed for me to go through the report is inadequate to give you a worthwhile opinion." Wallis was in "general agreement" with the design study: "… FFP have done a magnificent piece of work". However, he wanted to comment on several points which had not been covered in the study. He hoped to send the comments in about ten days, after completing work on a NATO supersonic bomber design. No response has been found in the archive.

In the course of the next year, more details emerged of Wallis's disenchantment with FFP. On 12 March 1959 (a year later), Bowen wrote White about an honorary fee (for his consulting services) of £1000 in Wallis's name to be presented to the RAF Benevolent Fund. In the 12 March 1959 letter, Bowen revealed some details to White. He reviewed the major contributions Wallis had made:

> … Barnes Wallis did play an important part in the design study. He was a strong advocate of some of the broader characteristics [which became part of the final design]; he was responsible for the present spiral structure of the dish surface [sic, really the spiral purlins in the backup structure], and for the all-important master equatorial concept which is likely to be a basic feature of future telescopes. …[Then Bowen summarised to White the current status of relations with FFP.] Unfortunately, towards the end of the design study he suffered some of the frustrations which I have been suffering myself during the past few weeks, and he lost patience with FFP. He told them to jump in the lake in quite colourful terms and, among other things, told them to forget about his fee.[77] This puts us in a very awkward situation, especially since FFP did not tell us about it [the break] very specifically at the time. Our responsibilities are quite clear, however, and we should go ahead and make the payment.

On 20 April 1959, Bowen (he was about to leave for the US the following day, after meeting Wallis in person on 17 April) wrote Wallis a letter of gratitude and apology: "I would like to emphasise again how grateful we are for the effort you put into our radio telescope project… I deeply regret that difficulties have occurred with FFP, but we have run into similar troubles

[76] Bowen was in a hurry since the final decision on the acceptance of the FFP study would be taken by R. Casey, the Minister for the CSIRO, in early February 1958.
[77] The timing of this outburst is not clear, possibly in the course of late 1957.

ourselves and can quite understand your point of view." Then a week later (30 April 1959) Bowen wrote to White again: "I have now had an opportunity of a quiet talk with Barnes Wallis. Unfortunately for us he has some hard feelings about the part he was able to play in the GRT and his relations with FFP." On 15 May 1959, Bowen continued his complaints. He provided to White a list of five frustrations with FFP. One concerned Barnes Wallis "We have the very unfortunate business of Barnes Wallis; he is still well disposed to us, but very outspoken about Roberts and his ways." In the end, despite extensive correspondence involving the CSIRO administration, Bowen and Wallis -during the years 1958 to 1966-, the fee was never paid. The biographical memoir of the Royal Society for Barnes Wallis (A. Pugsley and N.E.Rowe, 1981) contained no mention of the conflicts with FFP.

Bowen told Pugsley and Rowe:

> Bowen: It was Sir Henry Tizard who first suggested we should seek advice from Barnes Wallis and this we did in September 1954. He was immediately interested and in characteristic fashion came up with a variety of original ideas, many of which were incorporated in the final instrument at Parkes. The detailed design of this instrument was, of course, carried out by Freeman Fox and Partners of London, and the excellence and competence they brought to this task may have obscured the early contributions made by Wallis. He acted as consultant, first to C.S.I.R.O. and then for a period to Freeman Fox.

Pugsley and Rowe continued:

> His initial design, which shows striking similarities to that finally adopted, comprised a circularly symmetrical disk, supported near the hub, constructed of members arranged in geodetic fashion. But he wanted these members to be made effectively incompressible by servo-hydraulic control, or alternatively to approach the same ideal by spinning the whole dish about its major axis to provide constant radial loading. He argued strongly for a very large dish—up to 1000 ft in diameter—but cost limitations resulted in a final design of 210 ft diameter and no 'incompressible' members.
>
> ….Wallis thus stepped into the telescope field with real effect, and the Parkes Radio Telescope, completed in 1961, remains as a lasting memorial to his structural and mechanical skill.

ADDITIONAL NOTE 2. Press Releases, Prime Minister Statement June 1958 and Open Skies

On 30 June 1958, Bowen sent a press release to the Prime Minister's (Robert Menzies) office [78]: "In response to your telephone call last week, I am now sending two copies of a short statement giving the case for the GRT and the present status of the project." This was intended to be presented by the Prime Minister in the House.[79] A short history of the last 10 years' advances in radio astronomy in the UK and Australia was presented:

> This was accomplished with simple equipment of relatively low cost and some of the most fundamental advances were made for an expenditure of about 1/3 of the budget of the Radiophysics Laboratory or approximately one per cent of the budget of CSIRO as a whole. The stage has now been reached when the next instrumental step is a major one, namely the construction of a Giant Radio Telescope some 200 to 260 feet in diameter… The really exciting discoveries of the future will come only from large instruments of high collecting power and high resolution… having the same research potential as the giant optical telescope at Mt. Wilson or Palomar.

After describing the overseas grants, as well as "a number of benefactors in Australia"[80], the expected matching grant from the Australian government was described.

The history of the design was presented ("the diameter of the instrument will be 210 feet, the size which FFP estimates could be built for a sum of £A 500,000"). The statement contained an unrealistic completion date (August to September 1958) for the detailed constructional drawings and negotiated bids, in contrast to the actual date in mid-1959.

A major purpose of the statement was the official announcement of the choice of the initial Parkes site of 52 hectares. "It is an attractive park lands surrounded by low foothills and eminently suited to a wide variety of activities in radio astronomy." The statement concluded with a summary of the rationale for the construction of the GRT: (1) Australia was a pioneer of the science of radio astronomy; thus in order to stay at the forefront of this field, a new large

[78] NAA C3830 A1/3/11/4 Part 4.

[79] Based on the web site TROVE (Australian National Library) of digital media, no reference to this Press release has been located. Prior to the 22 November 1958 national general election in Australia, Menzies gave a speech about scientific research in Australia. This included the text: "In addition to what I have said on this matter in the Policy Speech, we will continue to give large and growing support to C.S.I.R.O., whose magnificent work has expanded enormously of recent years. In particular, experiments will be vigorously pursued into rain-making [by the CSIRO Division of Radiophysics] on which a good deal of valuable scientific information has already been evolved." There was no mention of the RPL plans for the GRT.

[80] The Australian contributions were exaggerated by about a factor of two.

steerable radio telescope was required. (2) A similar instrument had been built in the UK at Jodrell Bank at the University of Manchester. "It is of the utmost importance that one be built in the Southern Hemisphere to complete the coverage of the celestial sphere." and (3) The radio telescope project was "likely to enhance the scientific prestige of [Australia], to encourage further development of scientific activities and help retain our best scientific brains in [Australia]."

CSIRO distributed a press release for publication on 14 August 1958. Much of the text was similar to the Prime Minister's statement. The beginning of construction date was modified to the "end of 1958", and the completion was to be "during 1961". The enlarged site was discussed (166 hectares). An important new addition was added in the press release, a description of an "open skies" policy:

> The project is being carried out by the Radiophysics Laboratory, but it is in effect a national project. The optical astronomers at Mount Stromlo already work in close cooperation with the radio astronomers, and the facilities of the GRT will be available to any astronomer, Australian or overseas, who has a special problem which can be solved with the aid of the new instrument.

In reality, it was to be 1988 before the Australian Telescope National Facility brought a new comprehensive policy of "open skies" to Australian radio astronomy. Surprisingly, the press release of 1958 apparently did not appear in the press.

Additional Note 3. Advice from Pawsey to Minnett (November 1958). FFP issues

On 13 November 1958, Minnett sent a letter to Pawsey[81], the acting Chief of RP during Bowen's absence ("Tailtwister" I in late 1958). Minnett was anxious to explain his actions to colleagues in Australia:

> Taffy's sudden departure from Sydney gave me no chance to advise once more against what I consider to be a premature visit to London. It seems he was determined to come at this time…. [M]y personal opinion about progress at FFP [is that] a later visit would have been more profitable. Fordham [managing partner of FFP] was upset… and naturally believed it was based on recommendation from this end [that is Minnett himself]. Both Fordham and Roberts, who returned to London today, agree with me that the visit is premature. However, they welcome the opportunity to show Taffy what has

[81] NAA C3830 Z3/1/VIII

been done, and will try to make what use they can of the visit to help the project along.[82]

On 21 November 1958, Pawsey wrote to Minnett,[83] a carefully worded response with advice and a stern warning:

> I fully appreciate that you are in a most tricky position with a foot in both camp [RP and FFP] and too close to things to see the general perspectives easily….
>
> Firstly, if the GRT is to be built it should be done quickly or we shall be left behind. By quickly, I mean in about the time estimated by Roberts [completion by early 1961]… We are the ultimate users and it is our job to attempt to see that an adequate amount of effort is applied. This is a parallel activity to seeing that FFP is supplied with adequate technical information which is what you have concentrated on. If a job is going slowly we must put pressure on FFP to do all they can to expedite it. This may well involve extra expense on FFP's part and our interests may clash. …
>
> Taffy's visit is exactly on these lines – to put pressure on them and to assess the general position. In my opinion we are now getting behind schedule, [but Roberts claimed that the project was on schedule]. In July [when Pawsey had been in London] I could see an awful lot to be done. But in the face of Roberts's assurance that all was going to schedule I could scarcely kick them. With the completion of the Metrovick contract still some time off after Roberts's estimated time has expired we are in a position to ask why.

Thus there were only three options according to Pawsey: (1) Minnett to apply pressure, (2) Bowen to start a "shock" visit to London ("Tailtwister I'") or (3) Bowen to visit sometime in the future after some of the technical details were resolved. Pawsey said that the choice between 2 and 3 was "dependent on psychology". With Taffy's choice of number 2, "this leaves you [Minnett] in the essential role of technical advisor to both parties but with your own interests on the side of getting the job done and effectively." Pawsey warned Minnett to investigate all issues with his own assessment of the total time for a job plus the "number and type of people working" on the project.

Pawsey's concluding summary was striking:

[82] Clearly Minnett was fearful that he would be blamed by FFP for the precipitous ("shock") visit of Bowen in late 1958- the "Tailtwister I" event.
[83] NAA C3830 A1/3/11/10, Part 3

> Also be very careful not to get placed in a position where you appear to be taking sides with FFP against Taffy on policy matter… Remember that we want to get the job done as quickly as we can, that Taffy's visit is a means to that end, and that **you must back him up in this**. [our emphasis]

Pawsey thus played a role in trying to make certain that Minnett would be effective in advancing the Australian point of view during the period that the FFP-RP conflict intensified. Clearly, Pawsey observed that Minnett could become pro-FFP due to his proximity to the FFP group in London.

Fig 1 – above. In 1957-1958, CSIRO scientists looked at a number of sites near Camden NSW along the Nepean River. Here Christiansen, Wild and Mills (left to right) were taking a break as Chris pretended to fish. The favoured site was Cliffvale near the Nepean River. (Image taken by George Day, David Nash collection). Also this figure is Fig 1 of NRAO ONLINE 48.