APPENDIX 3.3
Teleconference minutes, 18 December 1998 meeting

TELECONFERENCE - MINUTES, 18 DECEMBER 1998 MEETING

Attendance

1. The following persons participated in the teleconference/meeting:
   - Mr Jeff Harris (convenor) - ISR
   - Dr Caroline Perkins - ISR
   - Mr Des Davy - MARTAC
   - Mr Bruce Church* - MARTAC
   - Mr John Morris - MARTAC
   - Dr Mike Costello - MARTAC
   - Dr Keith Lokan - MARTAC
   - Mr Terry Vaeth* - MARTAC
   - Mr Garth Chamberlain – GHD
   - Mr Tony Ryan – GHD
   - Mr Leo Thompson – Geosafe
   - Mr Jack McElroy* – Geosafe
   - Dr Pat Lowery* – Geosafe
   - Mr Craig Timmerman* – Geosafe
   - Mr Dale Timmons* – consultant to Geosafe
   - Ms Sharon Burnell (minutes) - ISR

* - INDICATES PRESENT FOR TELECONFERENCE SEGMENT ONLY

Agenda item 1: Introductions

2. Mr Harris welcomed all participants to the meeting. Participants introduced themselves and their respective roles in relation to the oversight, carrying out or providing advice to the ISV process being carried out at Maralinga.

Agenda item 2: Purpose of the meeting

3. Mr Harris stated the purpose of the meeting as being to:
   (a) clarify areas of MARTAC concern with ISV to date;
   (b) identify issues in relation to the staging of the remaining inner pits so that MARTAC's concerns are addressed and operational limitations identified; and
   (c) promote discussion on the specification of engineered pods.

At its MARTAC 13 meeting, MARTAC asked that MARTAC minutes be annotated to include mention of the fact that the advice, explanations, and so on, offered by Geosafe during the course of the meeting/teleconference reflect Geosafe's views and do not necessarily reflect those of MARTAC.

Agenda item 3: ISV to date

4. Dr Perkins asked the general question:

> *What does Geosafe believe it has achieved to date in its use of ISV in the inner pits and in its ability to both learn from, and respond to, the difficulties identified in earlier melts so as to improve the outcomes of the more recently completed melts?*

5. In response, Mr Thompson read Geosafe's response from the paper included as Attachment 1 (pages 1 to 4). In particular, Mr Thompson reiterated the point he had made in his presentation to MARTAC on ISV at MARTAC 3, that the main role of the vitrified mass was that of an intrusion barrier and suggested that:

   (a) in all of the pits treated date, the ISV process has resulted in converting the friable mass of debris and soil into an intrusion resistant barrier which has eliminated the potential for catastrophic subsidence and inadvertent intrusion over the long term, with the overall result being that the process has resulted in a substantial reduction, if not the virtual elimination, of the long-term risks presented by the untreated pits;

   (b) experience with the operation of ISV in the pits has meant that Geosafe has been able to make several improvements to the operations in the later melts, with the result being that, for example, higher melt temperatures have been achieved in the more recent melts;

   (c) Geosafe's expectations for the melts were based on assumptions that were found to be incorrect, with the resultant consequence that it had been difficult assess the melts; and

   (d) in light of the problems in detecting previously anticipated indicators of when a pit bottom was being reached, consideration should be given to reviewing the pit probing records for the remaining inner pits.

6. Dr Lowery, Mr Timmerman, Mr Timmons and Mr McElroy voiced support for Mr Thompson's comments. Mr Timmons reinforced Mr Thompson's statement that the variability of the geology on site has meant that the subtle signs Geosafe were originally expecting to see were missing.

Distance of refractory trenches from pit

7. In response to the question by Mr Davy as to why the refractory sand trenches at the pits had been constructed 1m from the pit boundary compared to the 0.5m defined as the operational variable in the Geochemical Design Plan, Mr Thompson:

   (a) agreed that the modelling which had been done for the melts had assumed a distance of 0.5m; but

   (b) when the process had first been translated to site, it was considered that the occupational health and safety risk of collapse of a 0.5m wide wall was unacceptable; and

(c) this, combined with Mr Thompson's belief that he did not necessarily have to melt steel, meant that Mr Thompson had made the decision to increase the distance to 1m.

8. Mr Timmons advised that although he had designed the melts to minimise the amount of calcium which goes into the melt, it was prudent for Geosafe to take the safe course and move the trenches further out. The friable nature of the soil is such that a real risk of collapsing walls exists and consequent worker risks.

Self-sweeping of contaminated material down by electrodes

9. In response to the question put by Mr Davy as to what thoughts Geosafe had to deal with the apparent problem in the process of the downward, 'self-sweeping' of steel (in which the steel is, in effect, swept down past its true depth by the advancing electrodes), Mr Thompson advised that he could possibly see such a situation happening with respect to, for example, a bolt, but could not see bulk waste or contaminated soil moving down. Mr Thompson advised that there is not such sufficient strength in the system to push bulk waste down through the underlying soil.

10. Mr Timmerman stated that the ISV melt creates a sintered zone, or barrier or skin to the melt in which the sand particles are transitioning from the soil into the molten glass. Anything that is down below the melt, such as metal plate, bolt etc would become incorporated into the sintered zone before it has even had a chance to experience high enough temperatures to cause its deformation or melting. Even if that occurred, it would be likely that the metals would be within the sintered layer between the melt and electrode (and whatever other penetrating device maybe forcing it downward), and it would simply ride on the bottom due to gravity effects.

Movement and corrosion of electrodes

11. Mr Davy asked:

(a) whether there is a better way of countering the 'tooth effect' (in which the centre base of the melt is to a lesser depth than the depth of the melt at the electrodes), than using the approach suggested by MARTAC of melting down an extra 600mm and holding the electrodes steady for as long as possible towards the end of a melt?; and

(b) if collars have been used in the past to reduce corrosion of electrodes, why are they not being used now?

12. Mr Thompson responded by saying in relation to the tooth effect at pit 3, that he:

(a) was surprised at the bottom shape of the melt and that based on the modelling results he had seen, he had not seen any heat distribution pattern which would explain the significant arching at the 3.5m electrode spacing used;

(b) did not know the mechanism which caused the effect; and

(c) could not say if the effect would be produced at the different melts in a consistent manner.

13. Mr Thompson suggested that:

    (a) MARTAC's suggestion for melting an additional 600mm past the probed base would seem appropriate; but

    (b) to address the problem of oxidation at the electrodes which would occur if the electrodes were held stationary for a few days (as suggested by MARTAC), Mr Thompson suggested a better approach was to move the electrodes, inserting them a 100mm or so every shift after the base of the pit had been reached.

14. Mr Thompson suggested that:

    (a) although melting an additional 600mm after the pit base does add calcium (and possibly some silica to the melt), it was his impression that once you have the melt to the bottom of the pit, if the temperatures were hot enough at the pit base before the melt moved further down, then it is probably not an issue if the melt temperature then begins to decline off when the bedrock below the bottom of the pit begins to be processed; and

    (b) so long as temperatures of the order of 1600°C are wanted only up to the point at which the base of the pit is starting to be incorporated into the melt, such temperatures can be achieved. It is unrealistic however, to expect to maintain melt temperatures of the order of 1600°C 600mm below the base of the pit when large amounts of base bedrock have been incorporated into it.

15. In relation to the use of collars, Mr Thompson advised that collars have never been used in association with moving electrodes, only with static ones which have the highest potential for failure. So long as electrodes can be continued to be moved at some rate, Geosafe can minimise the potential for failures. Given the fact that failure of electrodes does not affect the quality of the melts and the collars have not been used before on moving electrodes, Mr Thompson expressed the belief that it would not be cost effective to try and design for the use of collars on moving electrodes.

16. Mr Thompson suggested that a simpler idea, if electrodes were to be held stationary, would be to open up the hood and use the telescoping bucket to put some soil around the electrodes (this would only be contemplated, however, when the bottom of the pit is reached and dip sampling and temperature measurements were completed).

17. Mr Timmerman advised that his only experience with non-movable electrodes was back in the 1980s.

18. Mr Timmerman advised that the only times Geosafe had seen the tooth effect was in the 1980s when stationary electrodes had been in use. In such situations, he stated there was an opportunity with heat transfer of the electrodes below the melt, to melt downwards around the electrodes and not centrally. In the 50 plus melts Geosafe had since completed in the US, mostly flat bases resulted with possibly only a 'dimple' of at most 15cm below the bottom of the melt showing. Mr Timmerman expressed surprise at the bottom formation at pit 3 and that given the lack of data available, he was not sure if it was something particular to pit 3 or something potentially more widespread.

19. Mr Timmerman hypothesised that the possibly high metal content at pit 3 could have be limiting the heat transfer if the metals had been piling up in the centre of the melt and thus creating more melting around the hotter portion of the melt near the electrodes.

20. Mr Timmerman stated that melting to the additional depth is one of the easiest ways of achieving melting to the centre base of the pits and stated that one can eliminate the problems associated with having additional calcium that would be incorporated into the pits by going the extra depth.

21. Mr Timmerman advised that move to the use of engineered pods could eliminate the incorporation of additional calcium by designing the pit chemistry accordingly.

22. In relation to the collar issue, both Mr Timmons and Mr Timmerman suggested that the alumima sleeves form a wetted surface with silicate melts and will weld themselves to a cold cap that will also increase the chance of breaking electrodes. With anything other than the graphite electrodes, any metal sleeve will make an adherence with the glass and this will cause some sticking of the electrodes and may cause other failure mechanisms.

23. In relation to the use of moving electrodes, Mr Timmerman advised that the dynamic, downwards movement of the corrosion based area from primarily the surface of the melt will minimise any oxidation problems. Typically, one only might have a problem towards the end of the melt where the depth rate of movement slightly slows down due to the fact that much of the mass growth is in the lateral direction. Since the oxidation concern occurs only from about the 5m plus depth, this should not be a problem with the Maralinga pit melts.

24. Dr Lowery suggested that the high metal content in the centre of the melts might be a contributing factor to the tooth effect and that by holding the electrodes off the bottom of the pit towards the end of the melts and feeding them down slowly, the tooth effect might be countered.

25. Dr Lowery advised that he had not seen such significant tooth effects elsewhere in the Geosafe Corporation melts.

26. Mr Davy asked if Geosafe could quantify what it meant by ‘high metal content’ and what this meant for the setting of an objective for the concentration of metal to be placed in an engineered pod?

27. Mr Timmerman stated that although important, it is not so much the overall loading of metal that is at issue, but rather the concentration of metal in the centre between the electrodes.

Engineered pod situation

28. Mr Thompson suggested that:

    (a) in an engineered pod, if one wanted to measure the contour at the base of the melt, one could map it out using a range of type ‘C’ thermocouples a couple of feet above and at the base of the melt (if one had a flat bottom to the melt, then all the thermocouples would burn out at the same time. If, however, a group of thermocouples in the centre region burnt out only after the outer ones, then that would indicate there was type of ‘hump’ in the middle); and

(b) if a layer of refractory sand is used at the bottom of the pit, this would retard progress lower than the base at the electrodes and give the middle a chance to catch up.

29. Mr Timmerman advised that what is being done now with respect to going the additional 600mm below the probed depth is probably a reasonable approach with respect to ensuring the entire pit contents are incorporated into the melt, but it has a negative side in that it adds additional unwanted calcium to the melt. Mr Timmerman was not able, however, to offer a better, easier to implement alternative.

30. Mr McElroy suggested, however, that the fact of going an additional 600mm down means that melting of the high refractory sand at the side acts as a counter by increasing the temperature.

31. Mr Timmons suggested that, assuming the target goals are known, it will be relatively easy to design and stage a melt in an engineered pod.

32. Mr Harris asked Mr Timmons if Geosafe would be able to reach temperatures at the base of the engineered pods that will melt steel. Mr Timmons, Timmerman, McElroy answered yes, but reiterated that the expected outcomes of the engineered melt must be defined first and the materials to be put into the pods would need to be readily available at site (which it is expected to be the case).

33. Mr Thompson made the point that what is meant by the term 'bottom of the pit' must be defined and agreed to. Temperatures of the order of 1600°C could readily be achieved within a few inches in the melt, up from the bottom of the melt. However, in areas at, and just inside the fusion zone, where melting is just starting to take place and soil is fusing, such high temperatures cannot be achieved.

34. Mr Thompson advised that achieving the desired temperature within the melt is:

(a) primarily a matter of composition; and

(b) the elimination of, as much as possible, such materials as limestone; and

(c) getting high silica content in the melt.

35. Mr Thompson suggested that it might be useful for the last 300mm of an engineered pod where one wants to melt down through, to be filled with clean, minimal fluxed sand that will give clear indication to operators that the last of the debris is being incorporated into the melt.

Reactive nature of Geosafe

36. Geosafe did not respond to the question put by Mr Davy as to why Geosafe has not been seen to be the party to proactively offer solutions to problems and that such a role has been left to MARTAC?

37. Mr Morris commented that both the initial Geochemical Design Analysis and other Geosafe documents provided prior to work commencing in phase 4 were pretty good and that MARTAC had expectations that have since appeared not to have been met. This has led to a belief amongst some MARTAC members that Geosafe has been slow to react to the problems and difficulties that have developed during the melts, such as problems in ensuring the temperatures

achieved in the melts, the assessment of when to terminate a melt and sampling.

38. Mr Morris made the point that even though Mr Thompson believes the melts are now progressing in a more conservative manner, the melt at pit 19a and others since then, have been no less conservative than some of those of more recent melts. The concern is that pit 19a does not now appear to have been as conservative as it should have been, and that it was originally thought to have been terminated in a very conservative manner..

Comparability of earlier and later melts and electrode penetration rate

39. Mr Morris expressed concern that:

(a) one of the operational parameters has been changed, namely, electrodes are now being held in suspension rather than being allowed to sit on the bottom; and

(b) because of electrode oxidation and breakage, we are currently not getting probed depths at the base of each of the pits.

40. Mr Morris stated that, as a result, it will be difficult to compare the earlier with the later melts. He further stated the belief that the electrode penetration rate is likely to be an important factor in deciding whether or not there is significant possibility and probability that the whole of pit contents have been inducted.

41. Mr Morris expressed caution in the use of pit probing information carried out by Geosafe to both accurately define the pit base and in relation to decisions as to when to terminate melts. The pit probing data should be seen as a valuable indicator but should not be considered as absolute.

Ca/Si ratio – heat balance and temperature

42. Mr Morris questioned the use of the Ca and Si ratio as a guide to the melt temperature that can be achieved. Mr Morris pointed out that Mr Timmons had based his work on temperatures at100 poise, but excavation to date now suggests that 100 poise was not being achieved and that temperatures were neither high enough, nor sustained long enough, to melt steel.

43. Mr Morris asked what, quantitatively, will adding extra silica to the melt and/or reducing the calcium in the melt do for the melt temperature, and why?

44. Dr Lowery pointed out that when you put power into a melt, energy is either lost out through the top (if there is no overburden), or it results in an increase melt rate out the side, or in an increase in melt temperature. Dr Lowery suggested that:

(a) for a given soil, the preference seems to be for an increase melt rate rather than an increase in melt temperature; but

(b) if the chemistry of the soil is adjusted so that the soil has a higher melting point, then one effectively increases the viscosity so that at a given temperature, a melt that has a more refractory composition:

(i) will be more viscous (and, therefore, convective effects will be less important);

(ii) the melt temperature can be raised more efficiently; and

(iii) the melt rate is not raised as rapidly.

(a) if the melt is high in calcium, increasing the power would cause flow patterns in the melt to become more vigorous and increase the melt rate in preference to just increasing the melt temperature; and

(b) flow patterns set up in the melt are the dominant mechanism of energy distribution.

45. Mr Timmerman supported Dr Lowery's comments and stated that the composition of the melt is the primary driver in determining melt temperature. The power input density into the melt is chosen so as to establish an effective melt rate of the order of 1 – 3cm/hr and this is done by looking at the heat transfer and heat flux parameters of the melt. Heat transfer and heat flux can be varied by adjusting the composition, such as by adding Si.

46. Mr Timmons suggested that calcium in melts tends to promote crystallisation, and that the calcium levels in the melts at Maralinga might be why crystallisation is being seen in the Maralinga. Small bivalent cations (Mg, Ba, Pb etc) in the melt are responsible for decreasing viscosity in silicate melts. If you reduce these bivalent cations and increase the melt in Si, Al ions, then one can get dramatic increases in viscosity.

47. Mr Timmons added that increasing the viscosity of a melt also increases its resistivity, thereby increasing the ability, in some cases, to get higher power factors and higher temperatures in a melt.

48. Mr Thompson advised that heat balance requires dealing with a delicate balance of a lot of melt parameters, including:

(a) electrical;

(b) fluid flow;

(c) thermal conductivity; and

(d) density, and so on.

49. Mr Thompson advised that if more power is put into a melt, one effects certain properties, which in turn, because of their interdependencies, affect other properties. Ultimately, what is being looked at is a heat balance so that if more power is put in to the melt, the melt moves faster, more heat is convected to the sides, with the result being that the heat flux there is greater at the boundaries and a possible increase in the melt rate.

50. Mr Thompson stated that in addition, heat losses through the top of a melt can be significant. For example, heat losses out the top of a 4MW melt could be of the order of 2MW at Maralinga. Operations, therefore, are aimed at putting the highest amount of useable energy into the melt without wasting it.

51. Dr Lowery pointed out that the TEMPEST model they use addresses the interdependency of the various factors and models all the phenomena concurrently. If power input is increased, the increase in the rate of melt is much more than the increase in temperature.

52. In response to a query from Dr Costello as to where a temperature of 2000°C had been measured in a melt Dr Lowery had referred to, Dr Lowery responded that such a temperature had been measured in an engineering scale melt that

Geosafe had done in the US. The temperature had been measured using a type 'C' thermocouple located beneath the melt and was inserted in the body of the melt at the core between the electrodes. Dr Lowery advised that although he was not advocating aiming for melts at Maralinga of the order of 2000°C, such high temperatures can be reached using the ISV system if you have soils that 'want to' operate at such temperatures (namely, in high Si/Al, very viscous, very high resistive melts).

53. Mr Thompson advised that during the phase 2 trials, temperatures of 1850 – 1900°C were often measured in the initial melts of the sandy cover soil and suggested that one can expect to achieve such temperatures (at relatively low power levels) in the first metre or so of soil at Maralinga.

54. Dr Costello commented that the temperatures in the middle or the top of the melt were not as important as that at the bottom. To achieve at least encasement or encapsulation of any unmelted steel, the melt temperature at the bottom of the melt had to be high.

55. Mr Morris and Mr Thompson disagreed as to whether or not the temperatures reported at MARTAC 12 for temperatures in the relatively high sodium content fluxed sand, indicated high temperatures (of the order of even 1800°C) were being reached there.

56. Mr Morris pointed out that the geology at Maralinga is variable and that at the base of the pits calcium levels may actually be low and silica levels high.

Remaining inner pits

57. Dr Costello asked in relation to the four remaining melts in the inner pits, 'how confident is Geosafe that at encapsulation of the material at least will be achieved?'

58. Mr Thompson stated that encapsulation is not so much a function of melt temperature but of ensuring that the melt grows from a lateral perspective and is deep enough. Mr Thompson advised that:

(a) from a lateral perspective, Geosafe is highly confident that melting is done far enough outwards; but that

(b) from a depth perspective, pit depth and its probing are issues and, as a result, Geosafe cannot be fully confident as to how much over melting is needed to give a high level of confidence.

59. Dr Costello pointed out that at pit 3, investigation shows a couple of steel plates at the edge of the melt that shows that the melt had not gone far enough laterally.

60. Dr Costello paraphrased MARTAC's expectations that:

(a) all the plutonium would be washed into the melt; and

(b) any plutonium that had not been washed into the melt, namely that which might be left on any unmelted steel, was at least encased or encapsulated within the melt.

61. In response, Mr Thompson said he was not aware that there were any plates at the lateral boundary of pit 3 but rather, that the metal being referred to had been contained within the inner core which had only been exposed when the

edges of the vitrified block had been broken away. Mr Thompson then asked from an encasement perspective “how good is good enough with respect to encasement?” Does that mean the plate has to be, for example, 300mm from the edge, or should it be at least 500mm?

62. Dr Costello volunteered a definition of ‘encasement’ as being that area in the geology surrounding the steel, which fused and then crystallised again. Mr Morris suggested that further investigation at pit 3 was warranted to determine if encasement was or was not achieved on the unmelted steel.

63. Mr Thompson suggested that it should makes a difference whether the steel/soil was un-encased at the sides or at the bottom of the melt. Taking a pragmatic slant, Mr Thompson suggested that if unmelted and UN-encased material is on the bottom, then MARTAC should go back to the fact that it would be improbable to get to with respect to inadvertent intrusion, and with respect to purposeful intrusion, it has been largely eliminated.

64. Mr Timmons stated although he could not visualise the piece of steel of concern at pit 3, it was conceivable that a piece of metal could follow a melt down as a melt progresses and be close to the edge of the melt yet still be encapsulated.

65. Mr McElroy stated he had seen pictures of the pit 3 and 19a reports done by Mr Morris and pointed out that in melt 3 there is metal at the bottom of the melt.

66. Mr Timmerman offered the comment that metals become entrapped within the sintered area and typically ride down as a molten slag. Mr Timmerman suggested that because at Maralinga there are such large mass quantities, the heat transfer mechanisms may not deform or totally melt the metals. He ventured to say, however, that the metal would certainly be encased in the melt and suggested that all the metal from the plates in the pit were contained in the sintered layer.

67. Mr Morris identified that he had been using the term ‘sintered’ differently to that of Geosafe, and had in fact been referring to the ‘calcined’ layer (ie. to the layer which has lost CO2) rather than the area of partially fused material which Geosafe refers to as ‘sintered’.

Uniformity of mixing and melt sampling

68. Dr Lokan questioned the uniformity of mixing in the melts and asked if it was possible to get a realistic estimate of plutonium content from almost any sample of the ISV product.

69. In relation to the issue of uniformity of mixing, Mr Thompson responded by expressing the views that:

    (a) apart from at the boundary edge of the melt, the melt, in particular, the core, is very well mixed;

    (b) therefore, to ensure representative samples are taken, samples need to be taken at an appropriate depth to avoid boundary effects; and

    (c) liquid dip samples should provide representative samples.

70. In relation to the issue of ability to determine Pu content of a pit from the samples taken, Mr Thompson responded by saying that:

(a) there is a greater chance that all the plutonium is transferred from the steel into the melt if the steel has melted (and this is a function of temperature);

(b) with appropriate residence time in the melt, temperatures in the melt can be lower and still have the plutonium transferred into the melts. If there is adequate residence time, the plutonium should be transferred into the melt at temperatures of only 1400°C; and

(c) if, however, the plutonium is embedded deep in cracks or on plates sandwiched in layers in the melts, and so on, the plutonium won't come off into the melt from the inner layers.

71. Mr Timmons pointed out that one tends to have higher viscosities at the edge of the melt, and that there is limited mixing within the first few centimetres of the melt edge. Mr Timmons suggested that this is of real benefit when you look at such things as the leach properties of the monolith because the monolith as very low or no contamination at the edge, but rather, all the contamination is thoroughly encased within the vitrified monolith.

72. Dr Lowery added that the ability of material which has been processed to come out of the melt is hindered by:

(a) the fluid mechanical properties of the glass itself; and

(b) once the material has been melted, Geosafe have studies to show that the partition co-efficient for the plutonium that gets out of the steel is of the order of 10^{-7} of the plutonium which was there initially.

73. In response to Mr Church's comment that Geosafe has yet to validate what was said about the partition coefficient under the Maralinga conditions, Dr Lowery advised that he has reports on samples which show very good mixing and which supports Mr Thompson's assertion that, assuming a fairly fluid melt, if the plutonium is in the glass, it will be well dispersed throughout the glass.

74. Mr Timmerman said that excellent mixing is expected and Geosafe's database on prior melts shows that once plutonium is in the main melt body, it is well dispersed.

Remodelling and validation

75. Mr Thompson further advised that, so as to maximise the likelihood that Geosafe will be able to ensure achievement of a target temperature of 1600°C:

(a) Mr Timmons will shortly:

(i) remodel the remaining outer pits with respect to what is known about the pits using the additional information now in on, for example, geochemistry, pit size etc, model it; and

(ii) model some of the pit melts already done so as to try and validate his modelling;

(b) Geosafe will look to moving the refractory trenches closer to the pit; and

(c) Geosafe will remove the layer or "green" carbonate sand from the top of the pits.

76. Dr Lokan suggested that although it would be useful to carry out the remodelling suggested that in the remodelling of some of the past pit melts and model upcoming ones, he wondered ‘how useful it is given the continuing great uncertainty in the pit contents?’ and ‘how vulnerable the gulf of that remodelling is, particularly with respect to temperature, to uncertainties in the pit contents?’.

77. Mr Thompson responded by saying they would look at a range of possible compositions in the pits and try and identify a credible, worst case situation and model on that basis.

78. Mr Timmons added that:

(a) as far as he could recall, an assumption contained in his earlier report was that the soil used to backfill the pits was the high silica sand that is prevalent at site.

(b) whether this assumption, and other assumptions, such as those of void space, and the presence of barytes and lead bricks, are true, are still not known; and

(c) the surrounding pit soil is of primary importance as they make up the dominant mass or volume incorporated into the melt.

79. Mr Timmons advised that to improve the predictability of what will be achieved in the melts, a conservative approach can be taken in the remodelling and, for example:

(a) assume the pits were actually backfilled with limestone rather than high silica sand; and

(b) where available, use surrounding soil geochemical data.

80. Mr Church said a critical concern of his rests in Geosafe’s ability to tie current to past work so that MARTAC can feel confident that it can rely on the results from the hundreds of Geosafe melts already carried out. Further, since the tooth effect has been found to exist, with unencapsulated metal in evidence, clarifying the link with past validation is important.

81. Mr Thompson suggested that, in relation to the inner pits being melted in-situ, the excavation and breaking open of the vitrified product is a good means of validating a number of MARTAC’s concerns, for example, in relation to the presence or absence of the tooth effect. However, in terms of validating whether all the Pu has been transferred into the melt, it is hard to do in a full scale melt even if the product is excavated since one does not know the starting inventory.

82. Mr Timmerman suggested that core drilling, as opposed to excavation, if feasible, would allow more absolute sampling that could address the question of plutonium distribution in the glass.

83. Dr Lokan responded by saying that he had always thought core drilling was to be carried out as part of the assessment of the total plutonium inventory.

84. Mr Davy added that what had been intended was that early sampling results were intended to guide the amount of drilling that was to be required. Mr Davy commented that we are at melt 11 before we are starting to get representative samples being taken.

85. In response to Mr Vaeth's query concerning intrusion resistance of the product, long term stewardship and validation, Mr Thompson stated that:

(a) he firmly believes that if there is contaminated soil or steel at the bottom of the melt product, associated relative risks are not inconsistent with the stewardship issue for any other parts of the site;

(b) in relation:

(i) to validation, Geosafe is continually improving its actions and the extent of lateral melting is okay;

(ii) to 'deep enough', Geosafe has limited ability to make that assessment and the pit probing records need to be reviewed and their validity considered more fully; and

(iii) Pu in steel, based on Mr Thompson's experiences in phase 1 and 2 of the Project, it is Geosafe's belief that the vast majority of Pu on the steel will have been transferred to the vitreous phase;

(c) remodelling and improving pit chemistry should improve the melt outcomes; and

(d) if MARTAC can accept relative risk at the melts in as pragmatic a way as it took in, for example, defining soil removal boundaries, then some uncertainty can be accepted. Nevertheless, what the level of uncertainty that is acceptable is something for MARTAC to decide.

Temperature profile

86. Dr Lokan asked for an explanation of a suggestion made to try to get a core melt temperature profile using a sheathed tube.

87. Mr Thompson said he envisaged improvements could be made to the thermocouple arrangements in relation to the yet to be staged pits and hybrid pods. In relation to the in-situ pits, Mr Thompson suggested that probably the best that could be done is to use a long probe and insert it to measure temperature at various intervals (such as 300mm, 600mm and 900mm, and so on intervals). The technique was used on the most recent melt with some success until the thermocouple failed at the 900mm interval.

88. Mr Thompson advised that Mr Ombrellaro was meeting with the manufacturer in Seattle so as to find out if the thermocouple life could be improved.

Treatment of remaining inner pits

89. Mr Church stated that:

(a) because of the lack of characterisation of the pits prior to the melting made every pit an experiment – assumptions not being met in relation to the %steel, %silica, % limestone, and so on;

(b) in-situ is a blind approach to making a good melt; and

(c) confidence that steel is melted or encased is begging; then

(d) one should not proceed with any more in-situ melts but go straight into using the engineered pods.

90. Mr Thompson again questioned what level of confidence does MARTAC have and thinks it needs with the process, and reiterated that, in relation to the remaining inner pit melts:

(a) with respect to the lateral melt, Mr Thompson is confident of encompassing or encasing the steel;

(b) with respect to the vertical melt depth, there is less certainty that there won't be any steel left on the bottom towards the lateral centre of the melt; and

(c) if a very high level of confidence is wanted in relation to the MARTAC parameters, then exhumation and staging in engineered pods is warranted.

Characterisation of pits

91. Mr Chamberlain made the points that:

(a) he was surprised that the lack of characterisation of the pits had not been identified earlier on in the melts by Geosafe as a cause of significant problem in the melts;

(b) with respect to encapsulation and pit 3, the steel is not encapsulated and therefore did not meet the MARTAC criteria;

(c) the question has to be asked whether or not MARTAC accepts that the criteria melt/encapsulation criteria does not have to be enforced; and

(d) in order to really have 100% confidence then the only option is physical investigation.

92. In response, Mr Thompson stated that:

(a) the actual size of the pits has been found to be an issue;

(b) the ISV process can deal with a wide range of variation (as shown in many other places) if a specific temperature at the base of the pit is not required; but

(c) if a minimum temperature is specified at the bottom of the pits is needed, then characterisation data on the pits is essential.

93. Mr Thompson asked what MARTAC defines as 'adequate' in relation to encapsulation of steel and melt depth and suggested that in relation to the belief that the melt at pit 3 did not meet the MARTAC criteria for melting or encapsulation, then if a pragmatic approach is not acceptable, then the melting of the remaining inner pits in-situ should be stopped.

94. Dr Lokan pointed out that ARL will not countenance the digging up of all the pits.

95. Mr Ryan made the points that:

(a) in relation to the appraisal of progress to date, Mr Thompson had made no mention of the MARTAC criteria and that since achievement of the MARTAC criteria was what Geosafe had been contracted to meet, Mr Thompson should make some comment on the matter; and

(b) in relation to Mr Thompson's view that the melting of steel did not have to be achieved, file correspondence and reports put out prior to the phase 4 commencing, the ISV process seems to be predicated on having the steel melted and asked when the view of not having to melt steel came about.

96. Mr Thompson stated in relation to the MARTAC criteria that they have been a difficult subject, and that as late as 4 December, they were still being 'tweaked'. In particular,:

(a) Geosafe has always had the intention of melting steel, but not to 100% level. The process does not melt steel for the sake of melting but rather so as not impede electrode movement. From a lateral perspective, Geosafe has virtually 100% confidence that the pit contents are treated and the steel and other debris is melted. Questions remains though as to whether or not there is vertical encapsulation;

(b) everyone has struggled to determine if there is a minimum temperature and what it should be? - 1600°C or as high above the melting point of steel as possible?;

(c) Geosafe is highly confident that most (90% or so) of the plutonium is in the glass phase. This is a difficult thing to verify.

97. Mr Timmons stated that in his modelling report, the intention was stated as to melt the steel for the purposes of preventing short circuits.

98. Mr Timmons defined 'melting' to include 'truly melting ' the steel or softening it enough so that it drops to the bottom so that it is removed from the vicinity of the electrodes.

Agenda item 4: ISV of remaining inner pits

99. Dr Perkins asked the general question:

> *How are Geosafe proposing to respond to the information and experience gained in the existing melts for the staging, carrying out and analysing the remaining inner pits?*

100. In response, Mr Thompson read Geosafe's response from the paper included as Attachment 1 (pages 4 and 5). Mr Thompson highlighted, for example, the following:

(a) recent action to minimise the amount of carbonates incorporated into the melts (such as movement of refractory trench closer to the pit and removal of the "green" carbonate sand from the top of the pits;

(b) changes to the improve the geochemical and melt product sampling carried out at the pits;

(c) changes to improve the placement and reliability of thermocouples measurements at the pits;

(d) changes to the design of the cover soil and sand trenches to maximise the likelihood of achieving melt temperatures of 1600°C; and

(e) changes to electrode spacing and power inputs to ensure complete melting or encasement of the steel.

101. Mr Thompson confirmed his intention to run a model for each of the remaining inner pits before they are done.

102. In response to Mr Thompson's comments, Mr Davy stated the view that:

(a) for MARTAC to have reasonable confidence that steel is being melted at various depths in the melt, then Geosafe must determine <u>in at least one</u> of the pits, the temperature gradient in the melt; and

(b) if MARTAC is to place any credibility on the figures for the amount of plutonium determined to be in a melt, MARTAC needs certainty <u>in at least one pit</u> that all plutonium has been transferred into the melt to start with and this needs to be solved before the remaining inner pits are treated. Mr Davy asked Mr Thompson to be prepared to discuss the matter further at MARTAC 13.

103. Mr Thompson responded to Mr Davy's comments by stating that:

(a) a temperature gradient can be determined in a future melt through the use of a more elaborate array thermocouples than previously used (but that MARTAC would first have to determine whether or not the gradient should be measured when the melt first reaches the bottom of the pit or later on when it is at the end of the melt); and

(b) if MARTAC would nominate a pit that is characteristic of the others and which might have steel at or near its bottom with the potential to have plutonium on it, then Geosafe could investigate the melt with the intent of trying to verify, as far as practicable, all the plutonium has been transferred into the melt. Mr Thompson suggested using the most recent melt at which there is the highest and best temperature for. No agreement was reached at the teleconference as to which pit to use and how to approach the task and whether or not ARL would accept/want an additional inner pit being broken up.

104. In relation to the question about transients involving the drums in a melt, Mr Thompson advised that it was a heat transfer problem and that the issue had been addressed in detail in the written answers provided to MARTAC members prior to the meeting.

105. In relation to Mr Thompson request for advice as to the best or preferred way to approach the collection of temperature data, Mr Timmons commented that the task is not easy and the melts appear to be very corrosive, complicating Geosafe's ability to get the measurements.

106. Dr Lowery stated in relation to the thermocouples that corrosivity and thermal shock going through the cold cap makes it difficult to take temperature measurements with thermocouples going in from the surface.

107. Mr Timmerman suggested that a possibility is to place type 'C' thermocouples as done in the past in the lower portion of the excavated trenches and to come in from the side of the melt.

108. Mr Morris echoed Mr Davy's earlier statement by stating that MARTAC needed to have a high level of confidence that the melt result is satisfactory and suggested a need for improvements to the geochemical sampling program. Mr Morris advised the meeting that although the samples he had received from

Geosafe for pits 19a and onwards provided useful background for MARTAC, the samples were too small and too selective to be considered representative, and hence would be of limited use in the geochemical modeling about to be done by Mr Timmons.

109. Mr Morris commented that assumptions in Dale Timmons' report as to the pit content and the nature of the soils in the pits had never been validated, and that one way to do it would be to take a look at a melt block, surrounding geochemistry, fluxed soil, and so on, but there is little information about the melt chemistry back yet.

Power input

110. In response to Mr Morris' comment that power input to the melts often ran at quite high MW values compared to the average MW figure, the average power input had fallen below the peak, Mr Thompson:

    (a) pointed out that earlier figures for average power which is reported includes the first 24 hours period in which a melt is powering up, but that reports now being developed will report the average power figure for the last 5 or so days of a melt; and

    (b) agreed that increasing the on-line efficiency was a good idea.

111. Dr Costello asked Mr Thompson how he could say that a 40kW trial was representative of a multi MW situation.

112. Mr Thompson referred to a graph included as Attachment 2 which shows heat loss versus power input and highlighted the balance point on the graph where the melt cannot deal with the extra amount of power in and the cold cap starts to melt and the heat losses start to increase dramatically with little additional power. In the region, just before the heat losses start to take off and go exponential, is probably the ideal operating range for a melt. Mr Thompson stated his belief that Geosafe have not been operating far from that ideal range.

113. Dumping say 10MW into the melt at that point will not yield more than probably 2MW of useful power.

114. Dr Lowery stated that as one starts increasing the power into a melt, the increase in power is first realised near the electrodes where the power density is greatest and if the power is increased too dramatically, one might get operational problems, such as making the melt too vigorous at the electrodes when one is trying to increase the whole of the melt temperature.

115. Mr Timmerman reiterated the comments made earlier in the meeting that the greatest effects of power input will be to the heat losses and to the heat rate. He also stated that operational trade-offs have to be are applied to ensure, for example:

    (a) an adequate melt rate without transients; and the

    (b) maintenance of the cold cap (to minimise heat flux losses from the top) whilst at the same time maintaining an adequate energy input to give an approximate 2cm/hr melt rate.

Energy-mass ratio

116. Mr Morris commented that in terms of the melt volume calculations and energy input, Mr Morris urged the validation of the assumption of the 0.7- 0.8 kWhr/kg of pit content being melted and suggested an opportunity might exist for pit 19a.

117. Mr Thompson advised that Geosafe was currently working on validating the energy-mass ratio kWhr/kg, and that based on existing samples (and with deletion of those samples which Mr Thompson believed to not be representative), values between 0.62 to about 0.9 had been determined for the melts.

118. Mr Thompson and Mr Timmerman both described the energy-mass ratio number as just one of the tools used to help validate mass which correspond with a dimension and cautioned that it should be interpreted in that context.

119. Mr Timmons stated he was now in the process of planning for the modelling which largely agreed with Mr Morris' comments in relation to the geochemistry, and so on.

120. Dr Costello stated that:

    (a) a lot of emphasis had been placed on the energy-mass ratio by Geosafe and MARTAC members in the past;

    (b) that he had little confidence in the kWhr/kg as it is a differential measurement (for example, how confident can one be that one is measuring heat losses?; and

    (c) that it is not a realistic parameter on which to make judgements as to the degree of pit contents melted.

121. Mr Thompson stated that although the kWhr/kg number has proven value as a rule of thumb, it is not an exacting tool and that it can change depending upon a number of factors (size of melt, heat loss factors etc).

122. For melts of a general size, Geosafe has found 0.7 – 0.8 to be a reasonable value range.

123. Mr Timmerman commented that ISV was never designed to be steady state but rather, is designed to melt the mass as quickly and safely as possible and move onto the next melt.

Determining depth

124. In relation to electrode depth probing, Mr Thompson advised that:

    (a) although periodically probing the bottom is a good thing to do, when the operators move the electrodes down at regular intervals, if they start to see evidence of shorting before shorting occurs, they stop; and

    (b) insertion rates provide an indirect indication of where the bottom and where the steel is.

125. In response to Mr Davy's suggestion that a neutron detector/probe might prove a useful tool in defining the bottom of a pit during pit staging, thereby providing verification that probing is finding the true pit depth, Mr Thompson said he would investigate the matter further.

Intrusion resistance

126. Dr Costello asked that intrusion should be qualified as inadvertent intrusion, and that a person with a backhoe would be attempting to deliberately intrude. No-one should be expected to provide a guarantee against deliberate intrusion.

127. Dr Costello further stated that inadvertent intrusion cannot be considered a possibility for plutonium under a block 200-300 tonnes in mass.

Thermocouples

128. Dr Lokan asked if it was realistic to contemplate placing type 'C' thermocouples into the lateral central of the pit either at or below the level of the bottom of the pit/probed depth.

129. Mr Thompson advised that

    (a) long type 'C' thermocouples were available;

    (b) a drill is available; and

    (c) providing there is no metal in the way to prevent the thermocouple from reaching the centre, a means for taking a temperature data point at the one elevation in the melt might be developed.

130. Mr Thompson pointed out that Geosafe could place thermocouples at 600mm below the probed depth of the pits if requested to do so [thermocouples are now being positioned at the probed depth of the pits].

131. Mr Timmerman pointed out, however, that there were practical difficulties in getting useful temperature measurements at the centre base of the remaining inner pits because of the potential tooth effect. In particular, when a thermocouple is coming in laterally, the tip may not be the first part of the thermocouple to come into contact with the melt. As a result, the thermocouple might erode or melt off half-way between the tip of the electrode and the refractory wall before the centre point is reached. Erroneous readings might be obtained.

132. In response to Mr Morris' question as to the reasons why the type 'K' and type 'C' thermocouples have had such different failure rates, Mr Thompson stated that although he did not fully understand the comparatively high rate of failure amongst the type 'C' electrodes, he suggested the failures may relate to the fact that the two types of thermocouples are used differently and the expectations on each is different to start with and the:

    (a) rate of corrosion/melting of the part in the melt;

    (b) temperature gradient between the plastic head and the wire at the end; and

    (c) their comparatively short length.

133. Mr Morris expressed disappointment that considerable effort and cost had been spent on thermocouples to date for little data in return.

Advantages of continuing with inner pits in-situ?

134. In response to Mr Church's question as to whether or not Geosafe saw a technical advantage in completing the remaining inner pits in-situ compared to exhuming and sorting into engineered pods, Mr Thompson offered the following comments:

(a) from a technical perspective, and in light of experience, if MARTAC wants a very high level of confidence of treating the pit materials, then restaging the remaining inner pit contents into engineered pods is a good approach to take, but if, however, a lower level of confidence is required with respect to the depth of treatment and the incorporation of all of the plutonium into the melt, then continuing with the in-situ treatment of the inner pits is appropriate;

(b) his personal view (and not necessarily that of others in Geosafe) is that wherever possible and wherever there is uncertainty as to pit depth, pit contents and the possible existence of compressed gas cylinders in a pit, then depending on the regulatory constraints which might be in place, his first preference from a purely technical perspective is to try and exhume the contents and restage it to eliminate uncertainties; and

(c) there are no technical advantages in continuing to treat the inner pits in-situ.

135. Mr Chamberlain and Dr Perkins advised there were significant practical scheduling/cost disadvantages that would arise if the remaining inner pits are not treated in-situ as previously agreed with the stakeholders.

136. Mr Vaeth suggested as an alternative, that before carrying out the last three inner pit melts, it might be useful for the next inner pit to be treated to be further investigated before melting commences so that some of the uncertainties associated with it (such as in relation to pit volume, contents and placement of thermocouples are resolved before the in-situ melting commences.

137. Mr Thompson voiced support for Mr Vaeth's idea of treating the next pit as a R&D exercise and suggested that it might be worthwhile to do some trenching in towards the pit so that a couple of faces to the pit is exposed which could then be investigated.

138. Dr Perkins asked that, in light of the limited time remaining available for the teleconference, that MARTAC 13 should be used to fully discuss the technical and other issues associated with the continued in-situ treatment of the inner pits and alternative approaches.

Agenda item 5: Design of engineered pods

139. Dr Perkins asked the general question:

> *ISR requires that the contaminated metal and other debris from the outer pits be treated in optimally constructed, configured and staged pits and Geosafe has the responsibility for the specification of these requirements. What is Geosafe's thinking for the design of engineered pods?*

140. In response, Mr Thompson read Geosafe's response from the paper included as Attachment 1 (pages 6 and 7). In particular, Mr Thompson highlighted the need for MARTAC to clearly define the criteria to be met in treating the contaminated contents of the outer pits in engineered pods, pointing out that:

(a) although it is relatively easy to design large scale melts to ensure achievement of temperatures of at least 1600 °C, the optimal design of the pods will vary according to what is to go into the pods;

(b) if it is acceptable to encase steel without melting it, then a lower level of control is required on what goes into the pod with respect to limestone material, concrete firing pads, bartytes brick wall sections, compared to the situation if all the contaminated metal has to be melted; and

(c) if full melting is required with a high degree of confidence, then minimal amounts of limestone etc should be allowed into the pods, with instead, predominantly high refractory materials being used to backfill the melts.

141. Mr Thompson highlighted the following additional matters as relevant to the design of engineered pods and requiring of detailed discussion at MARTAC 13:

(a) placement of steel in the pods;

(b) potential for the generation of gases and the prevention of transient events; and

(c) the inner and outer bounds on what is to be put in the pods.

142. Mr Timmerman, Mr Timmons and Dr Lowery voiced support for Mr Thompson's comments.

143. In response to Mr Thompson's comments on the matter, Mr Davy commented that since MARTAC had yet to meet face-to-face to discuss the engineered pods, he was only able to give his personal views on the matter at this time. Mr Davy suggested that:

(a) since the likely concentration of Pu in the engineered pod melts is likely to be much higher than in the melts to date, it is essential that the engineered pods be designed to ensure all the steel in the pods is melted and not just encased;

(b) inactive waste (such as barytes bricks) is not intended to go into the engineered pods (thereby minimising both the volume of waste to treated in engineered pods and the amount and types of gases which might be generated in a melt); and

(c) the engineered pods will need to be staged (such as through the use of an appropriate depth of refractory sand at the base of the pods) to prevent the 'tooth effect' and any unmelted steel 'riding' the melt down below the known bottom of the pods.

144. Mr Davy further suggested that although MARTAC will specify the overall performance criteria to be met, it is for Geosafe to define how the performance criteria will be met, and verified as having been met. It is up to Geosafe to define such things as the:

(a) nature of the backfill to be put into the pods;

(b) means for constraining the lateral melt; and

(c) shape and dimensions of the engineered pods.

Verification of melts

145. Mr Morris, Mr Church and Mr Davy variously suggested to Mr Thompson that, in addition to staging the engineered pods with appropriate arrays of thermocouples, he might like to investigate and consider staging the pods with a volatile material or an appropriate alloy which, for example, generates gases or puts a substance into the melt when heated to a suitably high temperature. Such an arrangement, if technically feasible, could then be used to complement the melt verification data to be gained from the use of the thermocouples.

146. Mr Timmerman advised that he had previously looked at the concept of using volatile materials in melts and that there was some merit in considering their use in the engineered pits. Mr Timmerman advised that several issues would need to be considered, however, before any decision was made on the matter, including the:

(a) availability of suitable, real-time analytical equipment to register the gases given off; and

(b) potential decomposition of the generated gases in the Maralinga melt environment.

147. Mr Thompson and Mr Timmerman suggested however, that, assuming improved reliability, thermocouples should provide a more effective and responsive indicator of the level of the melt.

148. In the course of discussions, Mr Thompson, supported by Mr Timmerman, suggested it might be useful to investigate using fibre optic depth transmitters to supplement the information to be gained from the use of staged thermocouples.

Warranty

149. Mr Thompson made the point that although Geosafe “have been, and will continue to do” the “best job possible”, Geosafe cannot guarantee the quality of the remaining inner pit melts and that if a guarantee was wanted, then the remaining inner pits should be exhumed and their contents treated in engineered pods.

Intrusion resistance of product produced in engineered pods

150. Dr Costello’s questioned how the intrusion resistance of the product produced in engineered pods compared to that of the in-situ product. Mr Thompson pointed out that although resistance against deliberate intrusion was a function of melt depth and the engineered pod situation could allow for deeper melts, less volume reduction and subsidence, Mr Thompson expressed the view that the two situations would be roughly comparable.

Relationship between in-situ and engineered pod design

151. Dr Lokan made the point that it is desirable to stage the engineered pods in such a way as to allow for verification of the interpretation of melt data obtained in the course of the inner pit melts. As a result, the engineered pod design should not be widely different to that of the pits already treated in-situ.

Preliminary design of engineered pod for discussion at MARTAC 13

152. Mr Thompson advised MARTAC members that with some guidance from MARTAC members, he would be able to put forward a preliminary design for the engineered pods, albeit with gaps in it for discussion at MARTAC 13.

153. Mr Chamberlain and Mr Ryan pointed out to participants to the meeting that:

(a) the degree of debris sorting and the subsequent placement of steel in engineered pods will be limited by the fact that such will be done using construction plant and not with pick and shovel; and

(b) the contents of the remaining inner pits cannot be controlled for but must be dealt with.

154. Mr Thompson acknowledged the need to consider such practicalities in the design of the engineered pods and what goes into them, but asked that every reasonable effort be made to exclude uncontaminated debris and soil from the original pits from going into the engineered pods.

155. Dr Perkins thanked everyone for their participation in the meeting and closed the formal part of the meeting/teleconference. The formal meeting closed at 13.00.

Agenda item 6: Other business

156. Discussions recommenced at 14.45 and continued without Mr Church, Mr Vaeth, Mr McElroy, Dr Lowery, Mr Timmerman and Mr Timmons being on line.

MARTAC's melt performance criteria

157. Mr Morris and Mr Davy made the point that the need to melt all the steel virtually all the time (and not just encase it) had been clearly stated on numerous occasions in discussions between various MARTAC members and Mr Thompson in the period leading up to MARTAC recommending to DPIE that it accept the use of ISV technology to treat the central Taranaki pits. Mr Morris stated that allowance for encasement of steel in the melt was added to the first MARTAC criteria to cover what were thought would be rare situations where less than 100% of the steel had been melted.

158. Mr Ryan pointed out the fact that all the documents associated with the project say things like 'melt steel'. For example, the Remedial Design Plan refers to 4 models showing 1600°C as the target temperature.

159. Mr Thompson stated that although he had anticipated that most of the steel would be melted most of the time, MARTAC's first criteria does nevertheless allow for encapsulation. Mr Thompson added that in hindsight, he had taken a defensive position that encapsulation was fine.

Electrode spacing and the hitting of metal

160. In response to queries as to why Geosafe (Mr Obrellaro) had advised GHD that the electrodes in the inner pit melts were never expected to encounter steel in their progress through the melt, Mr Thompson advised that the original assumption contained in the Geochemical Design Analysis was that since the pits were expected to be small, the electrode spacing in the melts to be used were such that they penetrated the area outside the pits, thereby, never directly encountering the steel.

Pit Probing

161. Mr Thompson advised the meeting that Geosafe could, if MARTAC thought it necessary, increase the precision of their depth probing to more consistently less than the 500 mm increments they had previously aimed for.

162. Mr Morris responded by stating his personal view that depth measurements to the nearest 100mm (plus or minus 200mm) would be an appropriate target.

163. Mr Thompson explained how the rate and pattern of movement of the 3 tonne probe through a pit was used to determine pit depth. In essence, the probe goes in relatively easy until it hits something. However,:

    (a) if it hits a concrete firing pad, resistance against further movement is registered, but the probe eventually breaks through and continues its downward movement;

    (b) if it hits limestone, downward movement will be slow but incremental; and

    (c) if it hits steel, movement ceases.

164. When asked by Mr Thompson for their input on the matter, MARTAC members were unable to suggest an alternative to the use of the 3 tonne probe to probe pit depth.

Heat fin effect and power levels

165. Dr Costello and Mr Morris stated that MARTAC had recognised the 'heat fin' effect (where there is enhanced thermal conductivity below the melt because of the presence of large metal plates and where the bulk thermal conductivity is at least 10 times it would have been had the plates not been there) as possible.

166. Mr Morris stated that he would not have expected to see any heat fin effect in pit 19a, as melting continued for longer.

167. Mr Thompson advised that Geosafe is using as much power input as is necessary to achieve good melts without going overboard.

168. In relation to electrode spacing and power input, Mr Thompson advised they are using the maximum sustainable power levels per unit volume (cf. the 3.5m electrode spacing and power inputs of 2.5-2.7MW with 4.5m electrode spacing and power inputs of 3.3 – 3.4 MW).

169. In response to Mr Davy's question as to whether or not there is likely to be some cavitation inside the melt with greater power loss, Mr Thompson said that there would be certain contact resistance between melt and electrodes and that resistance increases with increased power.

Over-melting

170. Dr Perkins asked Mr Thompson to explain what he meant by the term 'over-melting'.

171. Mr Thompson explained that he used the term to relate to depth and not to the lateral movement of the melts, and as a way of explanation, stated that if, for example, the target depth was 4m, then over-melting has not occurred until the electrodes have moved past the 4m mark.

172. Mr Davy pointed out that Geosafe needs to be very clear as to how their terms are used in the final melt reports.

Quantity of barytes bricks

173. Mr Davy asked how convenient would it be for Geosafe to run data to give total quantity of barytes bricks treated in the inner pits.

174. Mr Thompson advised that Geosafe is collecting data on this but have not been reporting it.

175. Mr Thompson agreed to Mr Davy's request to provide the data to MARTAC before the specifications for the engineered pods are completed.

Pit Plans

176. Using pit 6, melt 11data to illustrate his point, Dr Costello highlighted the fact that:

    (a) the thermocouple elevation views provided by Geosafe were not to scale and did not include the datum from which depth was measured;

    (b) there were inconsistencies between the words and diagrams included in the pit melt plans; and

    (c) that as a result, useful interpretation of the diagrams and pit melt plans was jeopardised.

177. Mr Thompson undertook to review and improve the accuracy of all pit plans and associated diagrams.

Engineered pod for contaminated soil

178. Mr Davy suggested that a pod be designed into which hot spots of contaminated soil could be placed and that the specifications for this pod could be less restrictive that those for the engineered pods used to melt steel in.

179. Mr Ryan stated that he expected:

    (a) larger debris to be put direct into the engineered pods; and

    (b) smaller debris to go into the trench where it is sieved and larger material transported to the engineered pods. Finer material and soil 'hot spots' were intended to be spread in a thin layer, with early survey by CH2M Hills.

180. Mr Davy voiced general agreement but stated that:

    (a) he could not imagine the regulator setting criteria for hot spots different to the category 'C' levels in the NH&MRC code [*Code of practice for the near-surface disposal of radioactive waste in Australia (1992)*]; and

    (b) the only uncertainty is inspection of the bottom of the steel and looking to see if it contains flaked off rust.

181. Mr Morris suggested that an alternative is to put contaminated soil hot spots into the burial trench at depth.

182. Mr Ryan stated that GHD were now working with ARL to define the sorting requirements to be applied in relation to the hybrid option

183. Mr Ryan asked Mr Thompson to:

(a) provide advice as to his sorting requirements; and

(b) his needs for layering of soil and debris in the engineered pods;

184. Mr Davy stated that it is intended to separate the steel from the uncontaminated bricks.

Geosafe input to MARTAC 13

185. Mr Davy asked Mr Thompson to prepare for discussion at MARTAC 13, a proposal for the engineered pods which assumes/allows for:

(a) the melting of steel (and not merely encasement);

(b) temperatures of 1600°C at pit floor

(c) excavation/sorting carried out to eliminate as much of the uncontaminated bricks as possible;

(d) all parts of the melt go past the known bottom location of the debris;

(e) the holding of electrodes (as far as possible) static to ensure the steel is melted, (duration and temperature to be factored in);

(f) a power rating to be used which is towards the limit of the power density;

(g) lateral extent of the melts to be confined;

(h) an engineered pod which takes into account the practicalities required by Theiss;

(i) a melt which is well instrumented in terms of obtaining a temperature gradient and limits the failure rate of the thermocouples as far as practicable; and

(j) if possible, allows for tracer release in accordance with melt progress.

186. Mr Davy added that it is up to Geosafe to define its needs in relation to the use of overburden, whether or not to open the hood and its use of materials to protect the electrodes when the electrodes are slowed to improve the effectiveness of the melts.

187. In response to Mr Ryan's comment that Theiss have been advised that they will need to lay 0.5m of refractory sand at the bottom of the engineered pods, Mr Thompson suggested that it might be more appropriate to place solid, high temperature refractory panels there which will not fuse.

188. Mr Morris stated that as long as the metal is melted right at the bottom, then it doesn't have to be encapsulated as it will have had all the plutonium sloughed off.

APPENDIX 5.3
Minutes of teleconference on status of bioassays

Subject

Maralinga bioassay (plutonium in urine) analytical status

Date

4 November 1999

Participants:

Bruce Coomer (CH2M Hill)

Bruce W Church (BWC Enterprises/MARTAC member)

Ernie Sanchez (ThermoNUtech)

Jeff Brown (ThermoNUtech)

Keith Baldry (GHD)

Garth Chamberlain (GHD)

The call began at 3 pm PST and ended at about 4:15 pm PST. Coomer and Sanchez began the call by reconciling what sample results were outstanding and what samples required reassessment to meet the sample analytical objective of 200 µBq as the MDA. It was determined that 3 samples were completed, but had not been reported to Coomer; 28 samples (since the establishment of the 200 µBq MDA was set) had not met the MDA, and 48 samples [this number increases to ~66 with the added QA samples that accompany the 48] (those analysed prior to the clarification of the 200 µBq MDA) were still to be reassessed. Sanchez commented that if had to recount all the 66 samples for 10 days, it would take until February 2000, to complete the counting.

There was discussion concerning the problems with reaching the desired MDA, with Sanchez affirming that sample volume, recovery of the tracer, and background at the time of counting were controlling factors in reaching the MDA. It was determined from this discussion that further solutions to the MDA question could not be determined until Sanchez evaluated each outstanding sample and determined if further analytical effort was merited. Sanchez noted that he would rather reanalyse the samples rather than just recount for longer periods, as this tied up his counters for long periods with little chance of improving the outcome (e.g. volume may not be sufficient; background may be the limiting factor, etc). For those samples with inadequate volume Coomer may be able to supply a new sample from archive, if available.

Sanchez accepted three action items:

- send final results on the outstanding samples (3), completed but not received by Coomer;
- review each sample not meeting the MDA (76) and advise what action he may be able to take (e.g. reanalyse, request more volume, re-count, etc).
- *write a brief action plan* accommodating his recommended further Lab activities. Sanchez indicated that this might be available next week.

A brief discussion was also entertained on what alternatives or options may be available to the 'client' (DISR) if the Lab (Sanchez) could not meet the specified MDA. These included evaluating the results from Harwell Scientific, sending those samples not meeting the MDA to a Laboratory using a more sensitive procedure (e.g. Fission Track Analysis), or developing a report by the joint project players explaining the situation with pertinent documentation of what the samples' results mean in the way of possible exposure to Pu and resulting dose.

Chamberlain expressed concerned from the client's point of view that with the analytical situation dragging on so long, maybe there should be a report explaining the situation. However, Church pointed out that until Sanchez performs the sample by sample review it would be difficult to write such a report. It was left that in approximately two weeks the MDA question would be revisited, with perhaps a second conference call to revisit the results and options.

Observations and commentary by Bruce W Church

With a project as short as the Maralinga Remedial Action was planned to be, it was natural for the HPRT team to expect fairly quick response to the team's recommendations. However, as the dates indicate in the letters to and from the Department and the contractors, considerable time elapsed from the date of completion of the audits until direction was given and a positive reply received. There were some exceptions, specifically with the increased environmental air monitoring in the operational area. The worst of these situations was the bioassay program, which took nearly two years to begin receiving urine samples completed with QA level three analyses recommended. The execution of the blind sampling program took equally as long, and the results are still unknown as the project concludes. Generally the Health Physics program was very conservative, probably more than was needed. It is expected that the operational data collected during the course of the cleanup will illustrate this point.

APPENDIX 5.4
Health and safety issues addressed at MARTAC meetings

M-12, AUGUST 1998

Communication and skin contamination

- Have just posted a '30 day snapshot' for the site which mentions the surveys carried out in the different areas and findings continuing to provide input at tool box meetings
- Waiting on Geosafe's reply as to their and AMEC's radiation monitoring information needs as employers

Bioassay program (urine monitoring for plutonium)

- Previously submitted samples have been located and can be recounted to the 200 level as a minimum
- Level 3 QA reporting on the reanalysed and future urine samples has been commissioned
- ThermoNUtech has been contracted to supply an 'unknown' for use as an external QA tool
- Expect to have data from the analyses by 20 October 1998

Mr Baldry/Mr Coomer will:

- report on analysis results as soon as possible after receiving findings;
- update the CH2M Hill implementing procedures for dealing with lost/incomplete urine samples; and
- organise the 'leaked' samples to be recounted if that can be done with confidence, otherwise, they will ask for advice from DPIE.

Airborne activity monitoring

- GHD recognises the need for the integration of data from the different monitoring systems and have almost completed their review of the Geosafe systems
- Two briefing sessions had been held for Geosafe/AMEC staff in which explanations were given on HP, what the monitoring readings mean, how the figures are combined and so on
- Personal monitoring procedure has been updated
- Use of lapel samplers will be addressed in a reissued environmental monitoring procedure
- Action continuing on the integration of the system data and documentation

Emergency response and evacuation

- Geosafe have arranged for real time SO_2 alarms to be installed at site
- Geosafe had run training for all workers at site on the emergency response and evacuation arrangements

- Geosafe have yet to run a trial of their emergency response and evacuation system but are expected to do so shortly
- A mock emergency recovery situation at a hood is planned to occur

Final dose assessment

- Had sought examples of dose reporting from Mr Church
- Were waiting on the recounted sample results
- Will develop a program for reporting results and clear it with ARL and DPIE

M-13, JANUARY 1999

Responding to a request from Mr Davy, Mr Coomer and Mr Baldry reported on the status of the implementation of the recommendations of the 1998 Health Physics Review, and also made some general comments about the general status of health physics-related matters on site.

Mr Coomer commented that CH2M Hill was just keeping up with the demand for their services in relation to pit preparations and the re-staging of the pits, and noted that:

(a) the off-gas filters were clogging up reasonably frequently (2-3 filters were normally needed per melt), and that it had proved to be labour-intensive to manually remove the contaminated particulate matter; and

(b) health physics support was needed when contaminated samples were dispatched from site for analysis at ANSTO.

Mr Baldry reported that the bioassays were lagging behind because the first recount of urine samples had been lost during a vacuum pump failure. The first batch of results was expected before the end of January, with a second batch due in mid-February, 1999.

Mr Baldry commented that the quarterly refresher health physics course (initiated because of the concerns of AMEC workers) was ongoing. Mr Coomer noted that AMEC workers were now far more confident when dealing with radioactive material, and seemed to stay cleaner during the operations. No instances of hand contamination had been reported recently.

Mr Baldry reported that although Geosafe had yet to install a two-stage alarm, all individuals carried radios on them at all times, and were in contact with a controller who would alert them to any potential hazard

MARTAC asked Mr Chamberlain to follow-up with Geosafe and ensure the prompt installation of the two-stage alarm system.

Mr Baldry briefed MARTAC on the status of the intended OHS audit at site, noting that he would confirm the terms of reference for the audit with Ms Burnell.

With respect to the stack Eberline detector, Mr Baldry reported that testing had not been completed, and that readings from the stack were not being used in dose assessments.

Dr Lokan suggested that ARPANSA needed a copy of the complete exposure records of all Maralinga workers, and not just their lung monitoring results. Dr Perkins undertook to discuss the matter with ARPANSA.

Mr Chamberlain noted that at the end of the project, GHD would hand over all the data on CD-ROM to DISR.

Mr Baldry reported that there were some outstanding issues that needed to be considered with respect to the dose and detection limits before an explanatory paragraph on the dose records could be sent to workers. There was some discussion as to whether a dose limit could be reported for the 'standard Maralinga worker', with Mr Baldry commenting that the dose limit could vary considerably depending on individual characteristics.

Dr Lokan suggested that a range of committed doses could be calculated using ARPANSA's minimum detection level and the 'standard Maralinga worker' parameters. It would need to be made clear that the committed dose was not an actual dose.

Mr Burns suggested that although a lengthy report would need to be written by ARPANSA outlining the relevant methodology, a short explanatory paragraph needed to be released to workers as soon as possible. There was general agreement that the summary paragraph and dose information should be released prior to the completion of the ARPANSA report to MARTAC.

M-14, MAY 1999

Items related to the HPRT review and reported on at MARTAC 14 follow.

- Mr Coomer advised that the spike sample had been received and that the final recommendations of the 1998 Health Physics Review pertaining to urine monitoring were being implemented.
- In response to questioning by Mr Church, Dr Perkins advised that DISR had yet to determine whether it would pursue the analysis of a selection of urine samples using a technique with a more sensitive 'minimum detection level' than that generally used.

M-15, AUGUST 1999

The following items related to the HPRT were discussed at the conclusion of MARTAC 15.

- Mr Baldry tabled a document titled *Bioassay Update* at the meeting, and discussed with MARTAC the approach to address the analysis delays occurring at Thermo NUtech's Albuquerque laboratories and to totally comply with the recommendations of the 1998 Health Physics Review Team's (HPRT) audit in relation to urine analysis.
- In relation to the HPRT recommendation that DISR give consideration to sending a limited number of samples to a laboratory for analysis using ICP-MS, Dr Perkins advised MARTAC that DISR had agreed to this being done and that Mr Baldry was taking action for this to occur. Mr Church undertook to provide contact details to Mr Baldry for the Brookhaven Laboratory that carries out ICP-MS.

- In response to a suggestion that the urine program was secondary to the lung monitoring program carried out for the Project, Mr Burns noted that, because of the variable plutonium ratios and solubility at Maralinga, urine monitoring may, under some circumstances, be of more importance than lung monitoring.
- Mr Burns advised that ARPANSA had received the quality control spike and blanks and mock urine recommended by the HPRT, and that these would be used, as appropriate, to QA the bioassay regime in the near future.
- Mr Burns questioned whether it might be useful and possible for some of the urine samples to be archived. Mr Baldry undertook to investigate the matter.

EXTRACTS FROM A MINUTE DATED NOVEMBER 28TH, 1991 ADDRESSED TO:

Mr. Pat Davoren,
Mineral Industries and Nuclear Policy Branch
Department of Primary Industries and Energy,
GPO Box 858, Canberra.
ACT

Dear Pat

I thought it might be useful to make a fast first pass through the Roller Coaster information that has come to hand so far. As you know, it wasn't looking too hopeful as you left, but, in the end, it has proved to be quite illuminating, and I'm sure you'll want to know about it. Would you pass a copy to Des, please? ------

Roller Coaster comprised four trials

Double Tracks (15 May 63) looks like a re-run of a Vixen B but with less HE – the cloud went to 220m rather than to ~760m.

Clean Slate I (25 May 63) had a different configuration from Vixen B, but, with nine-times as much HE as Double Tracks, the cloud went to 710m, rather like a Vixen B.

Clean Slate II and III (31 May & 9 Jun 63) were in bunkers, and they were for assessing the scavenging effects of different depths of soil overburden

Double Tracks in particular, and Clean Slate I as well, are of interest for our purpose.

The US knew before Roller Coaster – and further confirmed it then – that alpha-survey monitoring of Pu fallout on soil underestimates the Pu surface density by an order of magnitude, even when the survey is made in the day or so immediately following deposition.They attributed this to what they termed "weathering effects". From the studies in "Project 2.5 – Alpha Survey" they concluded that

(a) for alpha-survey monitoring of Pu fallout on a clean, brushed-concrete surface at ground level, the readings can be expected to fall by 1/6th to 1/10th or more over ~7 days; their observations in Roller Coaster gave a typical reduction of 1/10th in the first 3 days, and similar results had been obtained in earlier trials; and

(b) for alpha-survey monitoring over soil, a further reduction of ½ to 1/3 was observed, and a total degradation of 1/12 to 1/30 can be expected; whereas

(c) for 17 keV & 60 keV photon monitoring of Pu fallout on the concrete surface, the reduction to be expected is ½ to 1/3: and this monitoring method was strongly preferred.

No operational use was made of alpha survey monitoring over soil in Roller Coaster. The alpha-survey results came from measurements over 300x300 brush-finished concrete surfaces, set flush with the ground for this purpose, in a network of –7500 monitoring points extending over the downwind grid to 15km – quite an effort!

The most valuable piece of information protruding from under the wraps is in Appendix C of the Los Alamos National Laboratory report "Supplementary documentation for an environmental impact statement regarding the Pantex plant – dispersion analysis for postulated accidents" LA-9445-PNTX-D (December 1982). The center-line Pu deposition data for Double Tracks and Clean Slate I are presented and they are used there in demonstrating the validity of the Pu dispersion model DIFOUT which was employed in the impact assessment.

Generation of DIFOUT was one of the original objectives of Roller Coaster. The model rests heavily on the Roller Coaster observations for its concepts and input perameters: for example, the concept that "Most of the plutonium mass in the weapon-like assembly was aerosolized", and the assumption that the size distribution of the airborne particulate was as observed for the Double Tracks event.

The Pu deposition data in Appendix C are not expressed in absolute terms: they are normalized to one kilogram of Pu in the explosion – life wasn't meant to be easy!

"Although the actual plutonium amounts involved in the tests remain classified, normalized airborne and deposited plutonium dosages have been presented as dosage per kilogram dispersed under measured conditions. From these normalized dosages, scaling to higher plutonium amounts in the postulated accident cases can be done with reasonable accuracy if (1) the DIFOUT model can be shown to approximate the Roller Coaster experimental results and (2) the dispersion conditions of the accident cases are close enough to the Roller Coaster conditions to be considered applicable."

I have used this normalization as the basis for comparing the Double Tracks and Clean Slate I results with the post-firing alpha-survey measurements from the Vixen B trials and the EC&G aerial survey data from Taranaki. On the Figure:

(a)I have transcribed the plotted data from Figures C-6 & C-8 as Ci/m2 per kg of Pu, going from 100m. to about 40km down the plumes;

(b) I have added the values for the fallout plumes from VB1/2, VB1/3, VB2/2,VB2/5 & VB3/1 – which are all I can identify in the EG&G 241Am survey – converting them from 241-Am to 239-Pu using the appropriate activity ratios. They are plotted as the vertical bars, corresponding to the ranges of 241-Am surface density in which the EG&G results were reported;

(c) finally, I have included the post-firing alpha-survey results for VB1/1,2&3 and VB3/1, 3& 4 for which the plumes are unambiguous and we have good plots; VB1/2 gave two plumes, and, unfortunately, we have only a poor set of plots for VB2/1,2,3,4&5.

The figure tells the story quite well. There are three points – which neatly close the circle.

(a) The Roller Coaster data for Double Tracks and Clean Slate I, and the EG&G data for the five identified plumes at Taranaki, agree very nicely – given the differences in the firings, and the span of cloud heights and wind speeds.

(b) The values from the post-firing surveys beyond 100m. show a systematic 20-fold underestimation of the Pu surface density when compared with the data from either Roller Coaster or the EG&G work. The measurements were made by 1320 alpha monitoring over soil and the deficient outcome is entirely consistent with the US experience discussed in above.

(c) The values from the post-firing surveys within 100m. of the pads are consistent with the Roller Coaster data. These close-in measurements were made by 1320X 17 keV monitoring. The US experience at Roller Coaster was that this type of measurement is reasonably reliable – to within a factor of two or so.

(JOHN R MORONEY)
HEAD, RADIOACTIVITY,
AUSTRALIAN RADIATION LABORATORY