STATES OF JERSEY

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DEEP GROUNDWATER: LA ROCQUE AND ST. CATHERINE BOREHOLES (P.22/2007) – COMMENTS

Presented to the States on 22nd February 2007
by the Minister for Planning and Environment

STATES GREFFE

COMMENTS

Background information

1. Many of the Island's inhabitants share a deeply held belief that a substantial deep groundwater resource derives from underground 'streams' that flow to the Island under the seabed from mainland Europe.

2. That people hold personal beliefs is not being challenged. The Minister's concern is simply to ensure that the water resources in Jersey, on which the Island depends, are effectively managed for the long-term.

3. As part of this responsibility, an evidence-based scientific investigation to determine, once and for all, whether groundwater beneath Jersey is sourced from outside the Island was undertaken.

4. The investigation was meticulously undertaken and benefited from independent hydrogeological expertise from two leading institutions; the British Geological Survey (BGS) and Entec U.K. Ltd. The investigation was overseen by the Deep Groundwater Advisory Group (DGAG). The members of this group comprised equally of those who 'do' and 'do not' advocate that such 'streams' exist and discussion and agreement was sought during every stage of the investigation.

5. All DGAG members signed an agreement that stated, '*The definitive test for proving whether or not a flowing freshwater connection with mainland Europe exists will be to compare the isotopic signature of the water sampled from the two test boreholes with that of water from the surface aquifer*'.

6. A thorough scientific investigation based on the best independent scientific advice and principles has been successfully completed with the full co-operation and agreement of DGAG members. The methodology, the data and its interpretation has been extensively reviewed both by the BGS and Entec U.K. Ltd. The conclusions of the investigation are robust. There is no valid justification for withdrawing them or for spending further public money or resources in this area.

7. Members of the States of Jersey have been sent a summary report of the investigation. Further reports, including the comprehensive technical report, can be viewed at the Environment Division's web site http://www.gov.je/PlanningEnvironment/Environment/

8. In answering the questions raised by Deputy Baudains, the opinions of the two independent consultants, BGS and Entec U.K. Ltd. have been sought.

9. The replies to the questions raised demonstrate that Deputy Baudains' concerns do not distract or alter either the results or the conclusions of the investigation.

10. The conclusions of the investigation based on the two test borehole sites are that –

    i. there is no evidence to suggest that there are underground flowing freshwater 'streams' entering Jersey from outside the Island;

    ii. the isotope signatures and chemistry of groundwater from the test borehole at La Rocque are consistent with recharge from rain falling on Jersey;

    iii. the deep groundwater at La Rocque is hydraulically connected to shallow groundwater, so if you pumped water from depth, neighbouring shallow boreholes would be affected;

    iv. the deep groundwater at the two sites does not represent a separate major groundwater resource that would be capable of significant future development to contribute to the water needs of the Island.

11. These conclusions are supported by investigations undertaken by DGAG into the many traditional and anecdotal stories of freshwater streams. No evidence could be found to support such claims.

Question

The boreholes drilled at La Rocque and St. Catherine were created for research purposes – essentially to determine whether water from France reaches Jersey.

Unfortunately, the situation is now far from satisfactory –

(a) The sites were chosen by diviners, but within certain parameters. It was suggested they should be on the east coast, where landowners wanted boreholes, and, in the case of St. Catherine, moved to another area in order to save money.

Answer

12. The method statement of the investigation and the signed agreement both state that the two test boreholes sites and the depths of the predicted 'streams' at each site were to be identified solely by two members of DGAG; Mr. George Langlois (a water diviner) and Mr. Lewis de la Haye (a well driller).

13. The sites were to be located where these two members of DGAG considered that underground 'streams' flowing from outside the Island would be present.

14. Mr. Langlois and Mr. de la Haye stated that they were able to identify two such sites at a DGAG meetin held 12th April 2006.

15. The course of the 'streams' was divined by Mr. Langlois for some distance to and from the proposed sites. Mr. Langlois and Mr. de la Haye marked the final selection of each site with a white painted cross The drill rig was positioned and started drilling directly over this cross in the presence of Mr. Langlois.

Suggestion that sites should be on the east coast

16. Mr. Langlois and Mr. de la Haye were not restricted to sites on the east coast and were able to choose an location within Jersey.

17. Minutes of a DGAG meetings (7th and 21st March 2006) confirm that Mr. Langlois and Mr. de la Hay themselves provisionally identified two test borehole sites on the east coast.

Suggestion that sites should be where landowners wanted boreholes

18. Mr. Langlois and Mr. de la Haye were not asked to site the test boreholes where landowners wante boreholes. The St. Catherine test borehole site is, in fact, in a wooded area and the La Rocque site where the landowner already has a new borehole and is also supplied by mains water. Both test boreholes therefore have no immediate use and remain unused.

Suggestion that St. Catherine borehole was moved to save money

19. The borehole at St. Catherine was not moved to save money. The initial 'stream' identified by Mr. Langlois and Mr. de la Haye in late May 2006 bisected the road at Pine Walk, St. Catherine. The te borehole was, in fact, drilled some ten metres further along this 'stream'.

20. When this 'stream' was first identified, Mr. Langlois could not find an area of sufficient size to accommodate the drilling rig. He therefore looked at a site further up the same 'stream' at the top of Mont des Landes, St. Catherine.

21. It was later discovered that a rig could gain access close to the original chosen site. This reduced the total drilling depth thus increasing the accuracy by which the drill rig could intersect any 'stream'. The cost saving due to the reduced depth of the borehole was offset by the need for an access road to be built to get

the rig into the site. Again, Mr. Langlois and Mr. de la Haye identified the exact spot where the borehole was t be drilled.

22. No influence of the site selection was exerted on Mr. Langlois or Mr. de la Haye. DGAG members wer advised of the final sites selected in a letter dated 16th August 2006. No objections by DGAG members were received to either site and drilling proceeded as planned on 11th September 2006.

Question

(b) The goalposts appear to have been moved. The original exercise was to determine source. That now appears to have changed to proving the existence of deep water – which we all know exists in quantity anyway.

Answer

Changes made regarding the source of deep groundwater

23. Initially, Mr. Langlois and Mr. de la Haye informed DGAG members that the origin of 'streams' was in La Petite Suisse (DGAG meeting, 25th January 2006). The initial draft of the agreement therefore stated that '*the definitive test of the origin of the water samples will be by comparison of the isotopic signature of the sample from the test boreholes with that in the Petite Suisse region*'.

24. In a letter dated 22nd May 2006, Mr. Langlois and Mr. de la Haye indicated their dissatisfaction with th initial agreement and requested the reference to La Petite Suisse region to be removed as the groundwater source. Further, they recommended an agreement based on assessing a difference in isotopic signature between shallow and deep groundwater in Jersey. The rationale of the change was that if shallow and deep groundwater in Jersey has different isotope signatures then it must come from elsewhere.

Size and predictability of the deep groundwater resource

25. DGAG members acknowledged that, as well as the origin of groundwater, the size of the resource and how much can be safely extracted in the long-term was also an important consideration. This relates to the ability of an additional deep groundwater resource to supply future water needs of the Island (DGAG meeting, 7th December 2006).

26. The specification for the investigation was consequently drafted. This included that the test boreholes should be of sufficient completed diameter to allow proper pump testing and also to make possible the collection of all relevant information during the drilling process that would assist in quantifying the deep groundwater resource beneath the two sites.

27. During the investigation by BGS and Entec U.K. Ltd., collection of data of water inflows, flow rates and groundwater levels found no evidence of discrete, single underground streams. The careful assessment of all available data concluded that –

i. there was no evidence that single underground 'streams' were penetrated by either borehole;

ii. more frequent fractures in the upper granite provide greater flow and younger groundwater than in the deeper, less weathered section;

iii. the test yield obtained for the La Rocque borehole was above average but not exceptional, whilst that obtained at St. Catherine was very low and the water quality was poor and not potable;

iv. the groundwater at depth is hydraulically connected to shallower groundwater via a network of interconnected fractures and does not represent a separate major groundwater resource that would be capable of significant future development.

Question

(c) Halfway through the exercise it was admitted the isotope test chosen was incapable of differentiating between water originating in Jersey and water originating from nearby France. In fact, it is alleged the test result gave the same reading as water from nearby France.

Answer

Lack of French Isotope data

28. BGS and Entec U.K. Ltd. provided a joint presentation to DGAG on 12th April 2006 (prior to the letter from Mr. Langlois and Mr. de la Haye of 22nd May 2006 requesting significant amendments to th DGAG agreement). During the presentation, it was stated that there was a sufficient difference in isotopic signature for waters originating in the Petite Suisse area and Jersey to allow a definitive distinction to be made between the two sources. It was also stated that signatures for the Island and the adjacent coastal areas of France were likely to be too small to allow such a distinction to be made.

29. In recognising that nearby France has similar altitude it is also acknowledged that there would be insufficient driving head or pressure for a 'stream' to flow to Jersey from this area.

30. The quantity of isotope data from Normandy and Brittany is very limited, none being available for coastal areas adjacent to Jersey. Since no reliable isotope values exist for nearby France, it has never been 'alleged' that values were the same as those from Jersey.

31. A reliable and published groundwater isotope value exists for the Caen area (La Petite Suisse Region which will be similar to that for the Petite Suisse area) which shows a significant variation from the isotope values found in Jersey, proving that underground 'streams' do not derive from the area that was originally advocated as the source by Mr. Langlois and Mr. de la Haye.

The context of the investigation

32. It remains true that the isotope values in France are not relevant in the context of the current investigation (as specified in the DGAG Agreement) that was designed to test the difference between shallow and deep groundwater in Jersey.

33. The conclusion remains that –

i. isotopic 'signatures' obtained from the 'shallow' and 'deep' sections of each of the two boreholes are indistinguishable and are also consistent with the range of isotope signatures for Jersey groundwaters;

ii. there is no evidence to suggest that either the shallow or deep groundwater beneath Jersey has a source that is located outside of the Island.

Question

(d) It is alleged the borehole at St. Catherine provides very little water. Diviners are not noted for failing to produce water, so one must assume moving from the site chosen to a lower one in order to save money is responsible.

Answer

34. As mentioned above, the borehole at St. Catherine was drilled at the exact location and beyond the exact depth divined and identified by Mr. Langlois and Mr. de la Haye. The total depth was 5 metres below th point at which they predicted an 'underground stream' would be penetrated.

35. At the end of drilling Mr. Langlois was asked whether he wished drilling to continue. He replied that he did not.

36. The fact remains that, no single underground 'stream' was penetrated at St. Catherine. Only minor inflows and low yields were recorded with the water quality being poor and not potable. There was evidence of increasing salt water intrusion both with increasing borehole depth and as pump testing progressed.

Question

(e) The La Rocque bore is a disaster – wrong materials and procedures have resulted in a bore that, despite being re-drilled, is still obstructed halfway down, contains debris from a shattered lining, and bits of electrical cable (presumably from a failed attempt to fit a borehole pump). As such, as a test site or a supply for water, it is useless.

Answer

The suggestion that the La Rocque bore is a disaster – wrong materials and procedures

37. The borehole at La Rocque was drilled according to the specification as laid out in the methodology. Although drilling and completion diameters were specified, the casing material to be used was not, this being left to the preferences of the drilling contractors that were invited to tender. Both contractors that submitted tenders proposed the use of plastic (PVC) casings to be inserted into the section of the boreholes that were to be sealed using cement grout.

38. The plastic casing was never designed to provide an effective seal of the shallow groundwater. Hence, the issue of the damage to plastic casing during the drilling out of the cement grout is irrelevant and does not alter the conclusions of the investigation.

39. The seal was achieved by pumping liquid cement grout under pressure, to completely fill the borehole casing, borehole annulus and all of the fractures, fissures and joints adjacent to the borehole, (from which water inflow occurred) from 43 meters below ground level (mbgl) to the surface. Once the grout had hardened within the fractures it would be impossible to remove and would prevent any further inflow of groundwater from these horizons.

40. After the hardened grout was drilled out of the inside of the plastic casing, a watertight seal remained in the borehole. This comprised the grout filled fractures and a 25 mm (1 inch) layer of grout that set in the former borehole annulus from 43 mbgl to the ground surface.

41. The cement seal is therefore extremely robust and able to withstand considerable stress caused by drilling.

42. The presence of an effective seal was confirmed by the independent advisors to the project (BGS and Entec U.K. Ltd.) in a report entitled 'Clarification to questions relating to the construction of the test borehole at La Rocque, Jersey' that can be viewed at the Environment Division's web site (http://www.gov.je/PlanningEnvironment/Environment/). This report is attached for information.

43. The report highlights the complete absence of water inflow when the borehole was re-drilled to 43 mbgl as the conclusive evidence that the upper fractures were sealed out by the grout. Data of inorganic chemistry also provides proof that a seal was achieved. This absence of contamination by shallow groundwater permitted valid samples to be taken from the depth of the predicted 'stream'.

44. Mr. de la Haye was originally asked by DGAG to undertake the drilling and grouting of the boreholes despite his tender being more expensive than other quotes. Mr. de la Haye agreed to carry out the work However, his method of drilling would have only grouted the outer section of the casing and not the inside and outside as achieved by the present drilling company.

45. Three weeks before drilling was to commence, Mr. de la Haye informed DGAG that he was unable to undertake the work due to illness of his staff. At this time, Mr. de la Haye was due to sign an agreement detailing the specifications as per the investigation method statement.

46. The total borehole depth was specified as 50 m (some 5 metres deeper than the level at which Mr. Langlois predicted that the 'underground stream' would occur. Following discussions with Mr. Langlois and the Minister for Planning and Environment, drilling continued to a final depth of 55 metres below surface but as little additional water had been obtained Mr. Langlois agreed that drilling should be terminated at that depth.

The blockage in the La Rocque borehole

47. The isotope samples taken from depth were sampled during the drilling phase of the borehole when the drill bit penetrated down to a final depth of 55m. Once drilling was complete, a test pump and electronic measuring equipment were subsequently installed at a depth of 52 metres (3 metres above the total depth of the borehole). After completion of the investigation, the pump, all associated pipe-work and electrical cable was successfully removed from the borehole.

48. Although there is now a reported blockage half way down the borehole, at the time of the investigation the borehole was not blocked.

49. The blockage is reported to be within the cemented grouted section and was not caused by collapse of the borehole. Evidence of this is the recent film taken of the borehole column.

50. Viewing of this film suggests that remnant plastic casing attached to the borehole wall caused difficulty to get the camera gear down. This would not have prevented the heavier sampling pump from being installed and samples being taken from the required depth.

Question

Financial and manpower implications

I believe the La Rocque bore should be re-drilled at the Contractor's expense as it was his faulty workmanship that caused it to be useless. The St. Catherine bore was relocated at officer's request. I understand that not all the funds set aside for this experiment were utilised so I assume the Department has a balance sufficient to cover that one. Failing that, the cost will need to be met from the Department's revenue expenditure.

Answer

51. The evidence at La Rocque clearly demonstrates that an effective seal was achieved, thus isolating the shallow groundwater inflow horizons above that depth and preventing mixing via the borehole with groundwater encountered below that depth. Valid water samples were thus sampled from depths specified by Mr. Langlois as that where the'underground stream' were predicted to occur.

52. The test borehole site at St. Catherine was sited at a location identified by Mr. Langlois and Mr. de Haye in accordance with the agreed methodology. The siting of it was not influenced in any way and it had a very low yield of groundwater.

53. The drilling company stepped in at a late stage, after Mr. de la Haye had withdrawn. They constructed two boreholes that enabled a comprehensive and valid testing to be undertaken and the company provided an excellent service. There is no intention of asking them to re-drill either borehole.

54. The Environment Division has allocated considerable funds to this investigation. All the funds set aside were utilised. The conclusions of the present investigation are robust and give a definitive answer as to the origin and magnitude of deep groundwater in Jersey.

55. There is therefore no justification, and indeed no funds available, for continued expenditure in this area.

Closing remarks

56. The conclusions of the investigation are robust and unequivocally indicate that underground ‘streams’ flowing from outside the Island do not exist in Jersey.

57. There is no evidence at the two test borehole sites to indicate that the groundwater beneath the Island is anything other than that derived from local rainfall. It consequently represents a finite resource that could be easily depleted, endangering flora and fauna and the water resources for Island homes, if not managed in a responsible manner.

58. This research used an agreed scientific methodology, developed in cooperation with our most experienced diviners.

59. The value of further investigations must therefore be seriously questioned. As such, there is no intention of withdrawing the results or of spending further public money in this area.

60. The Minister for Planning and Environment is therefore committed, in the best interests of the Island, to bring forth the Water Resources (Jersey) Law to the States.

61. It is believed that resources and energy are best utilised in achieving this next logical and important goal.

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Clarification to questions relating to the construction of the test borehole at La Rocque, Jersey

08 November 2006

Introduction

As scientific advisors to the Deep Groundwater Advisory Group, the BGS and ENTEC have been asked by the Minister for Planning and Environment, Senator Freddie Cohen, to comment on questions raised at the DGAG meeting, 2 November 2006 concerning the construction of the test borehole at La Rocque.

A detailed site diary was maintained throughout the drilling of both test boreholes. Comprehensive records of the geology and drill penetration rate (for every 0.5m depth), together with air flush water yield, water temperature, conductivity and pH was also maintained. Groundwater samples for chemical and isotopic analysis were taken for each variation in penetration rate or water strike. These records together with the results of the chemical isotopic analyses have been used to address the questions raised.

Full documentation of the drilling and construction of the two test boreholes will be included in the final BGS/ENTEC report.

1. Evidence to prove that all surface groundwater above 43m was completely sealed off at La Rocque.

1.1 Air flush yields

The recorded variations in air flush water yield provide conclusive and robust evidence that all shallow groundwater flows, encountered above 43 mbgl, were successfully sealed out of the borehole by the grout emplaced above that depth.

Prior to grouting the borehole at La Rocque, the combined water yield arising from all fractures (the cumulative yield) was about 1 litre per second (l/s) at a depth of 10.5 mbgl, increasing incrementally between the depths of 10.5m and 43.0m to between 6.5 and 7.0 l/s. After grouting and re-drilling through the hardened grout, the borehole was completely dry until after the base of the grout was penetrated at 43 mbgl. This provides conclusive evidence that all productive fractures above that depth had successfully been sealed out by the grout.

The recorded water yield at 43.5m (0.5m below the base level of the grout) was only 0.6 l/s (Figure 1) but this gradually increased to 1.75 l/s at 55 mbgl, as an increasing number of fractures were penetrated below that depth. This much reduced air flush yield, together with the gradual incremental increase of yield with depth (Figure 1), is entirely consistent with the successful sealing off of all productive horizons above 43 mbgl and the yield solely being obtained from the deeper open section of the borehole below. Increases in yield obtained in the lower deep section of the borehole correspond closely to the occurrence of fractured horizons. There is no evidence of any rapid increase in yield, such as would be expected if the grout seal in the upper section of the borehole had failed or if an ‘underground stream’ were penetrated in the lower deep section of the borehole.

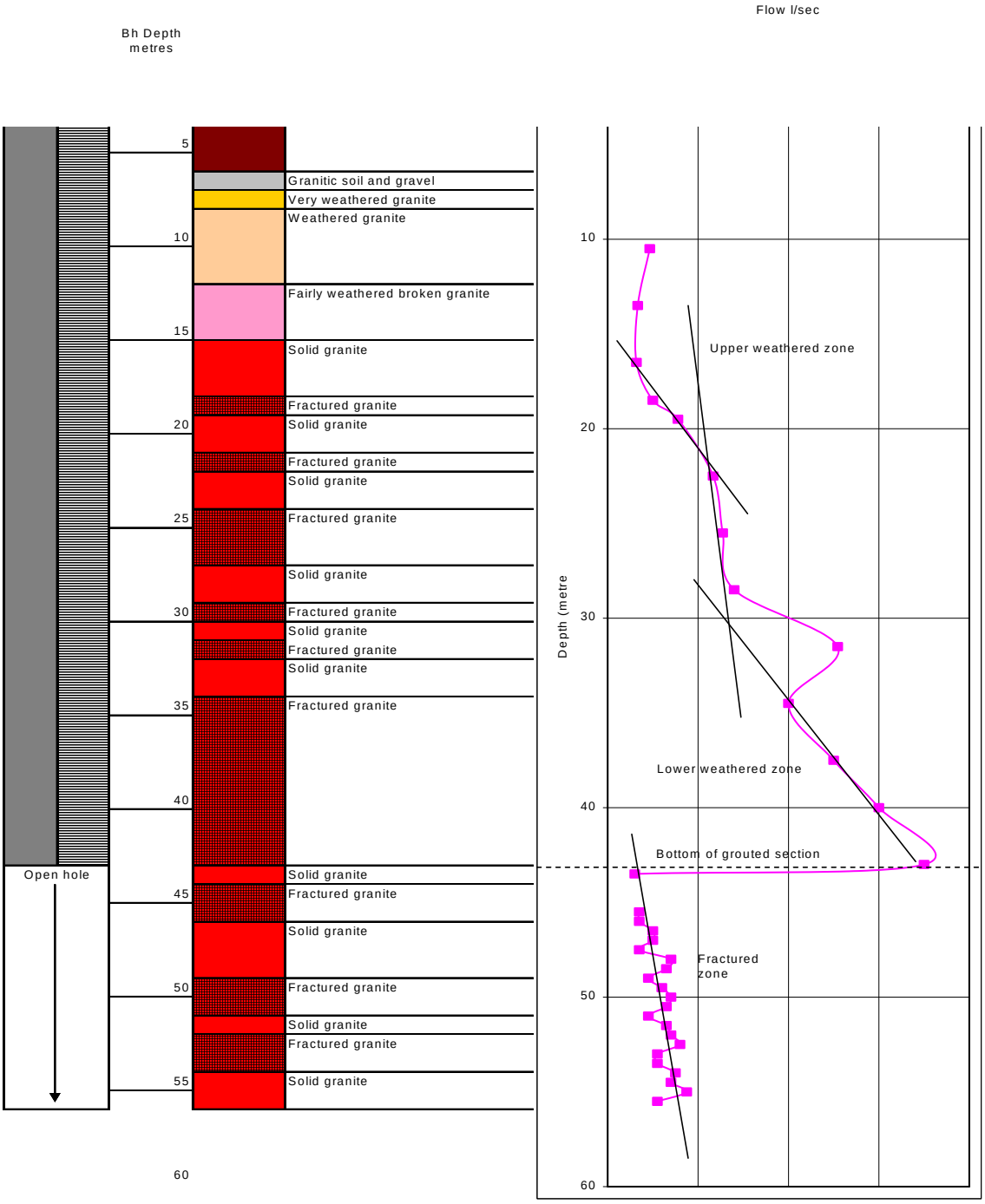

Figure 1 The geology and air flush yield of the La Rocque borehole.

1.2 Water chemistry

Groundwater was sampled for inorganic chemistry analysis at each change in drilling penetration rate and/or air flush water yield. Analysis results from the samples from 10.5 to 43 mbgl have a similar chloride concentration, this being representative of the groundwater from all of the inflow horizons encountered to a particular depth. There is little variation in concentration with depth (Figure 2). There is however a small but significant increase in chloride ion concentration for water samples obtained below 43 mbgl, likely to be indicative of an increased component of seawater. This distribution of chloride concentrations is entirely consistent with an effective seal having been emplaced above 43 mbgl, preventing flow and mixing from shallower horizons.

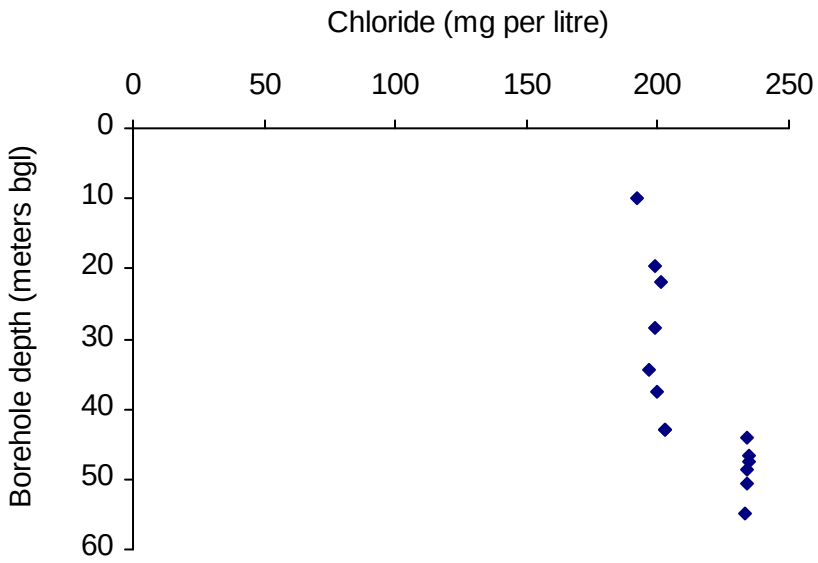

Figure 2. Chloride ion concentration with borehole depth.

1.3 Integrity of the cement grout seal

The seal emplaced in the upper section of the La Rocque borehole was achieved by pumping liquid grout under pressure, to completely fill the borehole casing, borehole annulus and all of the fractures, fissures and joints adjacent to the borehole, (from which water inflow occurred), from 43 mbgl to the ground surface. Pressure was induced by the weight of the liquid grout column within the borehole. Additional grout was pumped into the annulus, (the gap between the permanent casing and the borehole wall), to keep the borehole 'topped up' as grout penetrated the fractures adjacent to the borehole. Topping up continued until the grout level stabilised at ground level. Once the grout had hardened within the fractures it would be impossible to remove and would prevent any further inflow of groundwater from these horizons.

After the hardened grout was drilled out of the inside of the plastic casing, a watertight seal remained in the borehole. This comprised the grout filled fractures and a 25 mm (1 inch) layer of grout that set in the former borehole annulus from 43 mbgl to the ground surface.

2. The cement grout composition

Amplus consulted widely on the best grout mix to use to provide the most effective seal for the upper section of the borehole. After careful consideration a mix of 100 litres of water with 5 bags of cement powder was used.

Groundwater inflows occur from water bearing fissures, fractures and joints. The uncured grout mix had to have a high degree of fluidity to ensure maximum penetration of the grout into the fissures, fractures and joints penetrated above 43 mbgl, in order to completely seal out these inflows.

The addition of sand to the mix would have increased the stiffness of the grout and potentially prevented full ingress into such fractures.

A stiffer sand based mixture could also caused air pockets to occur in the borehole annulus as the tremmie pipe was removed, potentially compromising an effective seal.

3. Grout hardening

The grouting of the La Rocque borehole commenced at 1320 hrs and was completed at 1535 on 13 September 2006.

Drilling out the grout commenced at 1055 hrs on 15 September 2006.

The grout was therefore left to harden for 43.5 hours (a minimum of 24 hours was specified) before re-drilling started from the surface. Drilling inside the casing penetrated only dry hard grout.

Further, drilling of the bottom of the borehole was finally completed at 1200 hrs on 16 September 2006; a further time interval of 68.5 hours from the completion of grouting.

Rock chip samples were sampled and documented every half meter depth. The presence of hard cement chips collected from the depth interval between 43 and 44 mbgl (immediately below the base of the grout) is seen in Figure 3. This shows unequivocally that the base of the grouted upper section of the borehole (to 43 mbgl) had completely hardened and that no liquid or unhardened grout was present in the borehole.

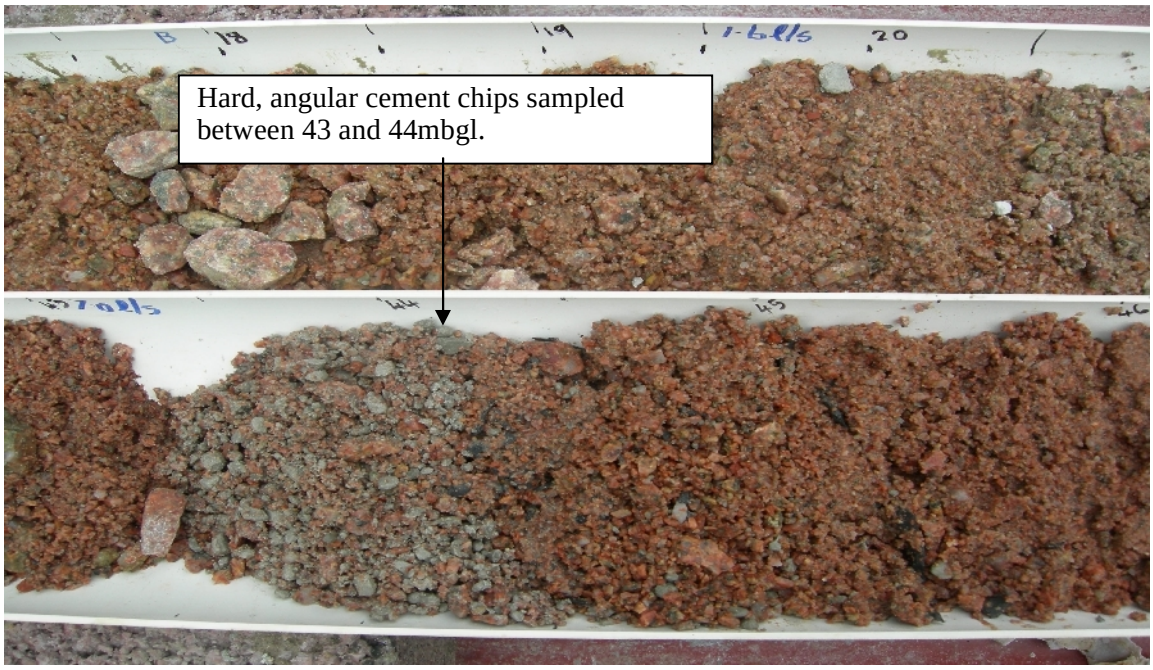

Figure 3. Rock chip samples collected every 0.5m during drilling at La Rocque.

4. The plastic casing

The grout was pumped into both the permanent casing and the annulus between the casing and the borehole wall. Therefore, no pressure differential occurred between the inside and outside of the casing and buckling of the casing was not an issue.

Damage to the uppermost 13 metres of the plastic casing did occur whilst drilling out the hardened grout. There is however no evidence that the grout seal over this section of the borehole was in any way compromised. Larger diameter steel casing was grouted into the upper section of the borehole to a depth of 10 mbgl, which would have assisted in preserving the seal. It is notable that no increase in air lift water yield occurred following the occurrence of damage to the plastic casing, as would have been anticipated if the grout seal had also been damaged.

5. Conclusions

The above evidence clearly and robustly demonstrates that;

1) an effective seal was achieved between ground level and 43mbgl, thus isolating the shallow groundwater inflow horizons above that depth and preventing mixing via the borehole with groundwater encountered below that depth.

2) all evidence indicates that the cement grout had cured (hardened) sufficiently to provide a totally effective seal between ground level and 43 mbgl.

3) the isolation of shallow inflow horizons has prevented any possibility of cross contamination of groundwater samples obtained from the depths specified by the water diviners and well drillers, as being where an ‘underground stream’ would be penetrated. There is no possibility that the validity of the results of analytical results for chemical or isotopic analysis, for water samples obtained from the deep open section of the borehole, have been compromised by leakage from the section of the sealed borehole above 43 mbgl.

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