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ENVIRON

November 15, 1991

BY FACSIMILE AND FEDERAL EXPRESS

Mr. Cesar Lee
Remedial Project Officer (3HW21)
United States Environmental
Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Re: Basis for Selection of Additional Home Well Sampling Locations

Dear Mr. Lee:

The purpose of this letter is to respond to your recent request for documentation of the technical basis for selecting which domestic wells to sample in the vicinity of Salford Quarry. As you know, boron is a naturally-occurring element ubiquitous in the environment. It would naturally be expected to be present in ground water, and a variety of human activities may be expected to contribute to boron levels in groundwater. These activities include the application of fertilizers and the use of detergents containing borates. Thus, the purpose of the additional home well sampling was to rapidly define the extent of elevated boron levels in ground water in the vicinity of the quarry. The additional sampling was implemented because elevated boron levels were detected in samples from three homes southwest of the quarry (the [redacted] These three homes, along with five other homes, were sampled in July 1991 in accordance with the approved Remedial Investigation Site Operations Plan (RISOP).

In early September 1991, wells at the three referenced homes were resampled to confirm the July 1991 results. Eighteen additional homes along Shady Nook Hill Road, Cressman Road, and Fawn Drive were also identified for sampling. These homes were selected, in consultation with the USEPA, based on their proximity to the three homes discussed above. The sampling of these 18 homes was conducted in September 1991. Based on the results of that sampling, 18 additional homes were sampled in October 1991. Thus, a total of 36 home wells (beyond those proposed in the RISOP) have been sampled.

In summary, the selection of residential wells for sampling was predicated on the following:

- The results of previous domestic well sampling around the quarry;

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- The apparent ground water flow direction as based on water level measurements from the monitoring wells around the quarry; and

- A general conceptual model for the occurrence and movement of ground water within the Brunswick and Lockatong Formations, developed from a review of the literature and the findings of the recent field investigations in the vicinity of the quarry;

Each of these factors is described in detail below.

In July 1991, ground water from 10 monitoring wells and 8 domestic wells was sampled and analyzed for all target compound list (TCL) and target analyte list (TAL) constituents and for boron. Prior to this, 20 domestic wells had been sampled in April 1989 for TAL metals, boron, and TCL volatiles. The boron results for all samples collected through October 1991 are summarized on Plate 1.

The data from these two sampling events indicated that higher boron levels were present in the on-site monitoring wells (MW1, MW2, MW4, and MW5) and in monitoring wells located west-southwest of the quarry on both sides of the West Branch of Skippack Creek (MW7, MW8 and MW10). However, the results indicated that the area of higher boron levels is bounded to the northwest of the quarry by MW6 and to the south by MW9; both of which contained boron concentrations within the expected range of background concentrations. The results of the previous domestic well sampling also showed that higher boron levels are generally not present north, east, southeast, and west of the quarry. In fact, in all but one well [redacted] boron concentrations greater than 1 ppm were not found in any domestic well along Quarry Road.

The July 1991 results indicated that the only domestic wells, other than the [redacted] with higher boron concentrations were clustered in an area southwest of the quarry. The results further suggested that this area was relatively narrow and that concentrations were much lower to the northwest, as evidenced by the difference in boron concentrations between the [redacted] residences on Shady Nook Hill Road. The sampling in September 1991 along Fawn Drive confirmed that higher boron concentrations are restricted to a relatively narrow band and that concentrations were significantly lower both northwest and southeast of this band.

In addition to the boron data from monitoring and domestic wells which indicated that higher boron concentrations are restricted to an area southwest of the quarry, ENVIRON has collected several rounds of ground water level measurements from the 10 monitoring wells around the quarry. These measurements suggest that ground water flow around the quarry is to the west-southwest.

If indeed the boron found in all wells sampled originates from the quarry, which has not been determined, both the historical analytical data and the ground water flow direction indicate that, higher boron concentrations would only be expected to be detected in a relatively narrow band southwest of the quarry. These two factors alone were sufficient

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to direct the sampling effort and select only those homes located southwest of the quarry for sampling.

In addition, however, ENVIRON has developed a conceptual model for ground water occurrence and movement within the Brunswick Formation in the vicinity of the quarry which further supports the sampling approach taken to date. This conceptual model is based on a review of the literature regarding the hydrogeological characteristics of the Brunswick Formation and observations made during the field investigations at the quarry.

As noted in the RISOP, the Brunswick Formation and Lockatong Formations[1] constitute the aquifer in the area of Salford Quarry. These formations consist of interbedded shales, siltstones, and sandstones, with little or no primary porosity. The Lockatong Formation is generally harder and less fractured than the rocks of the Brunswick Formation, and consequently is not capable of producing as much water as the Brunswick Formation (Longwill and Wood 1965; Newport 1971). Because both formations lack any significant primary porosity, ground water occurrence and movement are limited by the secondary porosity created by fractures and joints.

As described in the literature (e.g., Longwill and Wood, 1965; Newport 1971; Vecchioli et al. 1969, Michalski 1990) and as observed in the quarry itself, the degree of fracturing varies from bed to bed. The more highly fractured a bedding unit, the greater the probability that unit will produce ground water. Because of this phenomenon, the water-bearing zones are discrete, generally thin (< 2 feet thick), stratigraphically controlled bedding units. The drilling logs and geophysical logs of the monitoring wells around the quarry support this concept, with water producing zones encountered at discrete stratigraphic levels.

The bedding units within the formations are lenticular (i.e., not laterally continuous) and asymmetric, with the long axis oriented parallel to the strike of the bedding. According to Longwill and Wood (1965), the water-producing zones are relatively narrow in the dip direction but may extend for a few thousand feet along strike. Additionally, the primary fracture pattern is roughly parallel to the strike of the bedding. These two characteristics of the Brunswick and Lockatong Formations result in an anisotropic aquifer in which the degree of hydraulic connection within a water-producing zone is greatest along the strike of the bedding. As noted in previous submissions, the strike of bedding in the vicinity of the quarry is roughly northeast-southwest.

The less fractured rock units between the water-producing zones act as aquitards, generally restricting ground water movement. (Michalski 1990).

Data gathered during the installation and geophysical logging of the monitoring wells around the quarry revealed the presence of three distinct stratigraphically-controlled water-producing zones around the quarry. The shallowest zone was encountered in

[1] Although the Brunswick and Lockatong Formation have recently been subdivided and renamed, ENVIRON will refer to this unit as the Brunswick Formation because of its established use in the geologic and hydrogeologic literature for this area.

MW2, MW8, and MW10. This zone was not encountered in MW5 or MW7, however, indicating that this unit is not lateral continuous north and west of the quarry. Deeper water producing zones were encountered in MW1 and MW4. Figure 1 is a cross-section through the quarry illustrating the relative depths of the water-producing zones.

As noted in previous submissions and discussions, the most well-developed vertical fractures in the vicinity of the quarry are oriented subparallel to the strike of the bedding. Such vertical fractures may result in the interconnection of the various water-producing zones. However, it is not possible to predict the amount of interconnection.

In summary, water-producing zones within the Brunswick appear to be relatively thin discontinuous bedding units, which are oriented along the strike of bedding. These units are separated by thicker, less fractured zones which act as aquitards, restricting the movement of ground water. Vertical fractures that transect the aquitards may provide a pathway for the vertical movement of ground water between water-producing zones.

Although it has not been determined that the boron found in all wells sampled is migrating from the quarry, the conceptual model is consistent with the analytical results from the additional sampling. As shown on Plate 1, the area with higher boron concentrations occupies a relatively narrow, well-defined band oriented parallel to the strike of bedding. The edge of this band is marked by much lower boron concentrations. Based on the conceptual model and the sampling conducted to date, ENVIRON believes that it is unlikely that higher boron concentrations will be found in other areas not already sampled.

If you have any questions concerning the above information, please do not hesitate to contact us at 609/452-9000.

Sincerely,

Bill Stone

William A. Stone, Jr.
Principal

Robert W. North

Robert W. North
Senior Associate

WAS/RWN:crb
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cc: A. D'Angelo
D. Ewald
L. Kirsch
J. Owen
B. Pluta
S. Portman
R. Smith (3HW15)
L. Mata, Geonetics
B. Davis (3HW015)

J. Neubauer 11/20/91

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REFERENCES

Longwill, S. M. and C. R. Wood. 1965. *Ground-Water Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania.* Pennsylvania Geological Survey, Ground Water Bulletin W-22.

Michalski, A. 1990. Hydrogeology of the Brunswick (Passaic) Formation and implications for ground water monitoring practice. *Ground Water Monitoring Review.* v. 10, no. 4., p. 134-143.

Newport, T. G. 1971. *Ground-Water Resources of Montgomery County, Pennsylvania.* Pennsylvania Geological Survey, Bulletin W-29.

Vecchioli, J., Carswell, L.D. and H.G. Kasabach. 1969. Occurrence and movement of ground water in the Brunswick shale at a site neat Trenton, New Jersey. In *Geological Survey Research, 1969.* U. S. Geol. Survey Professional Paper 650-B. p. B154-B157.

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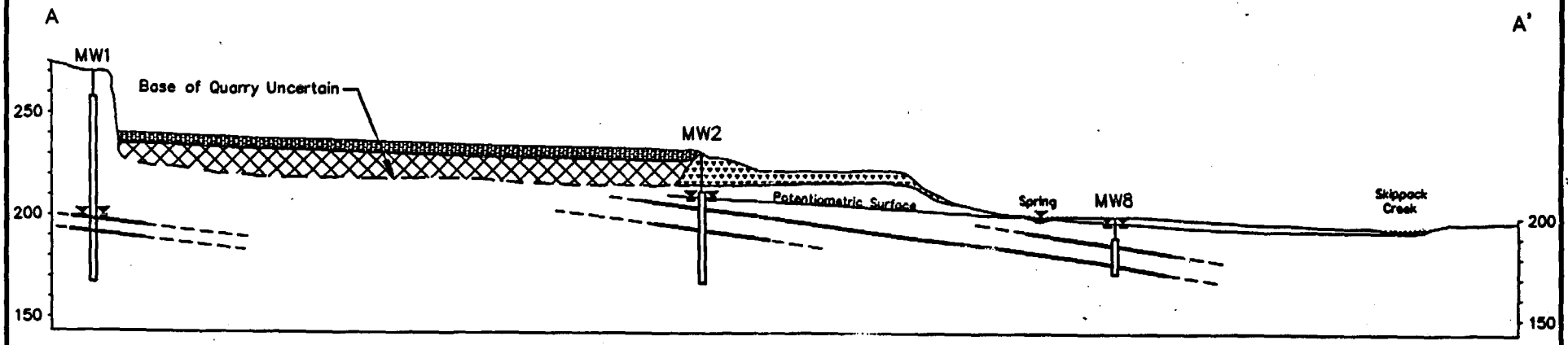

No Vertical Exaggeration
Scale 1" = 50'

Quarry Fill Material

Overburden/Fill

Clay Cap

Shale

Ground Water Level

Open Rock Well

Water Bearing Fracture Zone (Dashes Indicate Continuity of Fracture is Uncertain)

Note: Elevation is in feet above Mean Sea Level (MSL).

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Counsel in Health and Environmental Science

CROSS-SECTION A – A'
SALFORD QUARRY

Figure 1