Memorandum

GROUNDWATER SCIENCES CORPORATION

To: file

From: Stephen M. Fisher, P.G.

Date: March 6, 2012

Re: fYNOP Offsite Geological Mapping Activities

Geologic mapping activities were conducted in areas offsite to verify the presence of the Kinzer shale formation west and southwest of the site, and to determine if the shale is able to serve as a barrier to groundwater flow between the site and large carbonate rock quarry operations in West York. These carbonate quarry operations, specifically the Roosevelt Quarry, pump significant amounts of water from the operating pits to keep the pits dry for mining and discharge the water to Willis Run, a tributary of Codorus Creek. Concerns of the potential for pumping in the quarry to draw contamination westward under Codorus Creek and to the Roosevelt Quarry through connected karst carbonate formations has been expressed by project personnel. It has been proposed that the Kinzer shale formation would act as a barrier to this theoretical hydraulic connection between the two sites, therefore, verifying the presence of the shale formation as it is currently mapped was considered to be an important preliminary task for the project.

Mapping activities began on February 17, 2012 with the collection of structural bedrock measurements immediately west of the Harley site near the I-83 and U.S. Route 30 interchange. Several bedrock outcroppings of the Kinzer shale were measured along the northbound onramp to I-83 from Rte 30, in the parking lot embankment of the diner on Rte 30, and along Toronita Street. Dip of bedding in this area supported the mapped pattern of the formation with bedding dipping generally 25-30 degrees to the southwest. Several small outcrops of apparent Vintage dolostone were also inspected north of Route 30 and west of Codorus Creek. Measurement locations were accurately recorded by a handheld GPS and measurements collected with a Brunton compass. The focus of the field mapping continued south and west of the I-83 interchange with inspection of stream channels and embankments to search for outcroppings of the shale. Shale was observed in both a deeply weathered outcrop behind the Wingate hotel on North George Street and in a stream channel near I-83 and south of Rte 30 containing shale channel gravel and deeply weathered shale in the stream embankment, both of which verified the presence of the Kinzer shale in those areas. A single outcrop near the southwest edge of the fault block on which the site is situated was measured on the west side of Codorus Creek and south of I-83.

The Kinzer was also observed and measure in several places on the fault block located west of the site fault block in the area of Route 30, North George Street, and Prospect Hill. The relatively higher elevations of Prospect Hill are a result of the presence of the more-resistant Kinzer shale in the area. Bedding orientations in the eastern part of the Prospect Hill block were dipping to the southeast at approximately 30-40 degrees. Mapping continued in the southern part of the Prospect Hill block near the Gnatstown Overthrust, which defines the southern limit of both the site fault block and the Prospect Hill block, to confirm the continuation of the Kinzer shale to the south edge of the block. Few outcrops were seen in this area where Willis Run enters Codorus Creek. One very

good outcrop was observed and measured on the east side of Codorus Creek immediately south of an apparent plunging anticline on the Prospect Hill block (Photo1). The Kinzer shale has been mapped as subcropping as an easterly-plunging syncline that is terminated by the fault block just north of the Gnatstown thrust fault. The outcrop occurred at the mouth of a small unnamed stream and displayed the basal Kinzer shale unit and the contact between the Kinzer and the underlying Vintage Formation. This contact was observed to be a transitional contact with the siliceous knotty dolomite of the Vintage Formation and the basal shale of the Kinzer Formation. The transitional contact is characterized as earthy limestone (Photo 2) with interbeds of knotty siliceous dolostone (Photos 3 and 4) and some gray limestone and dolostone (Photo 5). This outcrop and the observed contact facilitated the redrawing of the contact between the Vintage and the Kinzer formations in this area as shown on the geologic map. The contact was drawn to honor the historical mapped carbonate pit between North George Street and Willis Run. While the bottom contact location changes significantly in this area, the shale continues to the south edge of the Prospect Hill block and maintains a continuous shale belt in the vicinity of Codorus Creek north of the Gnatstown thrust fault.

The observations made at the Codorus Creek outcrop were useful in interpreting the observations made along Toronita Street west of the Harley site. There, the contact between the Vintage and the Kinzer formations was moved westward to a point at Toronita Street where knotty dolostone was observed in outcrop near an earthy limestone that was within a few yards of good outcrops of Kinzer shale. The findings in this area suggested a transitional contact like that observed along Codorus Creek to the south and justified moving the contact further west. In addition, the documented average thickness of the Kinzer shale has been estimated to be about 200 feet thick by Stose and with dips in the area being about 25-30 degrees west, the thickness of the Kinzer shale belt in this area would be expected to be more consistent in thickness. As it is mapped on the project geologic map, the subcrop belt of the Kinzer supports the observations and assumptions, while honoring the topography in the area where the shale typically forms low hills and ridges like the one northeast of the I-83 interchange.

The Kinzer was also observed and measured in an adjacent fault block, northwest of the I-83 interchange along North George Street. Here the contact with the underlying Vintage was again observed, though not as well as along Toronita Street or Codorus Creek. The north end of an outcrop along North George Street exposed the knotty dolostone of the Vintage Formation that dipped southward under the Kinzer shale which was exposed over most of the outcrop (Photo 8). The contact was partially obscured in this area and the transitional beds were not visible. The bedrock measurements made in this outcrop required a slight adjustment to the orientation of the contact between the Vintage and Kinzer formations at the north end of the outcrop. It is uncertain whether the shale continues northward to the edge of the fault block at the North George Street interchange with I-83.

On February 22, 2012, mapping activities continued in the vicinity of an abandoned carbonate quarry along Sherman Street, located at the south edge of the site fault block, immediately south of I-83 at the Gnatstown thrust fault. Previous mapping suggested the subcropping of Kinzer shale at this quarry, however no shale was observed in the walls of the water-filled quarry. Likewise, no shale was observed in small outcrops along

Sherman Street just outside the quarry. Bedding measurements made in the east quarry wall and on the west side of Sherman Street outside the quarry were notably different and supported the location of the Gnatstown thrust fault where it is currently mapped. Bedding dip in the quarry was measured to be 19 degrees east, while bedding dip on Sherman Street was measured to be 67 degrees to the southeast. The southeast portion of the quarry wall was noticeably highly fractured, though no distinct fault plane was visible. Outcrops on Sherman Street appeared to be high calcium or marbled Kinzer limestone (Photos 6 and 7).

Mapping continued along Route 30 at the south edge of the Harley site where a plunging anticline has been mapped in the Antietam Formation. Measurements were made in the outcrop along the north side of the highway and confirmed the location of the plunging fold. Dips at the east end of the outcrop dipped southeast at 10 degrees and as measurements were made along the outcrop to the west, the dip directions rotated to the south dipping at 7 degrees, continuing to rotate to the west as one moved across the fold. Bedding dip on the west side of the fold was measured to be 43 degrees indicating the fold is asymmetrical, leaning slightly to the west. The eastern most part of the outcrop embankment was composed of predominantly sub-rounded to sub-angular quartz gravel with silt and sand soil suggesting the presence of an alluvial or terrace deposit on the east side of this fold.

Field mapping activities concluded with the observation of Harpers Formation phyllite at the fault contact northeast of the site, west of Codorus Creek. Harpers phyllite was noted in a large outcrop behind a fenced-in business at the west end of Amelia Drive and in a small outcrop at the east end of Hildebrand Drive. Both locations are very close to the block fault contact with the Vintage Formation. The Harpers phyllite was also observed along I-83 at the west end of the ridge formed by the Chickies Rock Anticline, immediately south of the northbound I-83 off-ramp at the North George Street interchange.

Photo 1: View east toward an outcrop along Codorus Creek showing contact of Vintage Formation with overlying Kinzer Formation. Kinzer shale is visible to the right, the transitional contact in center, and the Vintage dolostone to the left. Beds are dipping to the south (right).

Photo 2: Overhead view of earthy limestone at the top of the Vintage Formation at transitional contact with the overlying Kinzer Formation. Iron staining on surface due to the presence of weathered pyrite. North is to the top of photo.

Photo 3: View east of interbedded knotty siliceous dolostone with earthy limestone at top of Vintage Formation dipping to the south (right).

Photo 4: Eastward and downward close-up view of knotty siliceous dolostone of the Vintage Formation near contact with the Kinzer Formation from Codorus creek outcrop. Same rock type was observed along Toronita Street and North George Street at the contact with the Kinzer shale.

Photo 5: Eastward and downward view of gray limestone and dolostone of the Vintage Formation below the transitional beds at outcrop along Codorus Creek. Shows various joint sets and closely spaced jointing on the left. RR spike shows scale.

Photo 6: Westward view of high-calcium, marbled, laminated limestone of the Kinzer Formation exposed along Sherman Street. Steeply dipping surface on the left side of the outcrop is bedding.

Photo 7: Westward and downward close-up view of the high-calcium, marbled, laminated Kinzer limestone exposed along Sherman Street. Laminated bedding is visible.

Photo 8: Westward view of Kinzer shale in outcrop along North George Street with an apparent drag fold adjacent to a small fault. General dip direction is to the south (left).