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Installation of Shallow Groundwater Monitoring Wells in Singapore

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Singapore's Government and in particular its principal manager of industrial land, Jurong Town Corporation (JTC), have developed a very comprehensive approach to the management of potential soil and groundwater environmental issues via their Environmental Baseline Study (EBS) investigations. These investigations are undertaken on industrial land before tenants occupy the site, on their termination of lease and during lease transfers or changes of ownership. They are intrusive investigations that require a minimum of three groundwater monitoring wells to be drilled on properties of less than 2 hectares, with more boreholes required for larger parcels of land. The testing programs for the soil and groundwater samples is a comprehensive suite of analytes following those detailed under the Dutch Target and Intervention Values.

On the mainland of Singapore, the water table is found at shallow depths typically from 1m to 3m below ground level. The near surface and soil horizons up to 6m in western Singapore where most industrial activities are located and these EBS investigations are conducted typically consist of fill material underlain by fine grained soils of the Jurong Formation. Generally, the fill material will also be fine grained silts and clays but may also contain layers of sand and gravel. Drilling monitoring wells in these soils is usually done with small hydraulic rotary drilling

machines used predominately for geotechnical drilling. With the many uncertainties associated with environmental soil and groundwater analysis, being able to limit potential contamination introduced from the sampling process is critical. We have been very successful in using a comprehensive set of hand auger equipment and sampling devices with PVC casings to drill and complete shallow groundwater, monitoring wells for environmental soil and groundwater sampling helping to eliminate these uncertainties.

The hand auger equipment that we use is manufactured by Eijkelkamp. It consists of sand auger, mud auger, Dutch augers and sand bailers of various diameters that allow augering inside of the 90mm diameter PVC casings. Numerous advantages have been realized by using this technique in lieu of the more traditional geotechnical drilling machines. In a built-up factory areas site access can be difficult with a drilling machine whereas the hand auger methodology allows us to drill in areas inaccessible to a drilling machine. However, most important is the quality of the soil and groundwater samples. Traditional hydraulic rotary drilling requires water and most importantly for environmental boreholes, a clean potable water source. Other issues with drilling by machine relate to having potential hydrocarbon leaks from the drilling machine which could include diesel, lubricating oil and hydraulic oils. Obviously, all of these factors need to be controlled as to not compromise the quality of the soil and groundwater samples collected. For soil sampling the hand auger process allows us much easier decontamination of sampling equipment between boreholes and sample intervals, with no introduced water in the borehole and much higher sample quality with lesser amounts of cuttings to be disposed of as well. Determining depth to the water table is not obscured as this is a dry drilling process. Well development also produces less potentially contaminated water for disposal as no water is introduced during drilling. We have also found that this methodology can be more efficient as well, although drilling time with the machine is much faster than the hand auger for shallow wells. Moving the drilling machine

and associated equipment between monitoring well locations may require using a lorry crane and the set-up time for the machine usually results in more time taken to drill the well than by hand auger drilling.

There are disadvantages to the hand auger drilling method which includes, depth limitations, in sandy soils where casing is required to support the borehole. We are limited to depths of from five to six meters below ground level with the sand bailing process being very labour intensive. In cohesive soils where the borehole is stable below the water table, we have drilled as deep as 10m below ground level. Hard soils and no ability to core rock also make the hand auger method not viable. However, for much of our soil conditions in Singapore we have been very successful in conducting environmental site assessments for assessing shallow groundwater by collecting representative soil and groundwater samples that would have had limited potential for any cross contamination from the sampling process.