zone became unsaturated, leaving the potential for residual TCE to remain entrained within the soil matrix and or pore spaces. (See Figure 4 for a schematic cross section.) The proposed field program is designed as an initial phase of investigation to evaluate whether elevated TCE concentrations in mound area TSA water table wells are due to:

(1) Ongoing downward VOC migration from depth intervals below the TGA within the TSA mound source area

(2) And/or re-mobilization of residual TCE that has remained entrained within the soil matrix and/or pore spaces below the historical (pre-remedy pumping) TSA water table.

The findings will be used to support future remedial actions.

Approach and Rationale

A set of three vertically-profiled monitoring wells will be drilled and installed adjacent to existing Upper TSA well MW-17(ds), which is near the TSA mound source area at a location approximately central to the historical TGA plume footprint width. Additional well cluster locations west and east of MW-17(ds) are contemplated for a later phase of investigation and will build on findings from the currently proposed program. The wellbores will be drilled using rotosonic methods with a step-down seal for inter-aquifer protection. Continuous core soil samples will be retrieved for visual lithologic logging, grain size, porosity, and total organic carbon (TOC) sample analyses, and borehole field screening-level VOC sample analysis.

In addition to the borehole field screening level data, higher quality VOC groundwater and soil vapor samples will be collected from the vertically-profiled MW-17 cluster wells for laboratory analysis. The wells are intended to monitor locally wet and perched groundwater horizons, as well as unsaturated zone soil vapor at selected intervals below the TGA and above the TSA water table. As schematically shown in Figure 5, the well screens and sand filter pack installations will be constructed to monitor within the following lithologic intervals, based on records in the MW-17(ds) lithologic log (see Attachment A):

(1) 40 to 45 ft bgs: Wet sandstone horizon (SU1c) located just below the siltstone (SU1a) and claystone (SU1b) subunits of CU 1

(2) 55 to 60 ft bgs: Wet sandstone (TSA) below Confining Unit 1 but above the regional TSA water table, where perched groundwater was reported to be present during MW-17(ds) drilling in 1992

(3) 90 to 95 ft bgs: Unsaturated sandstone (TSA) below the historical pre-pumping TSA water level (80 ft bgs) and above the current TSA water level (102 ft bgs).

Groundwater levels, gradients, and VOC water quality will be monitored in the wells screened within the CU1/SU1b and perched TSA groundwater horizons listed above. If dry conditions should be encountered, the well(s) will be constructed for use in soil vapor VOC, pressure, and flow rate monitoring. The third well will be constructed to monitor soil vapor in a horizon that is currently

unsaturated but was saturated before remedy pumping began. The well sampling results will be used to assess whether TCE vapor concentrations are present at levels that may adversely impact TSA groundwater quality in the vicinity of MW-17(ds). MW-17(ds) is screened from 96.5 to 106.5 ft bgs, just below the proposed soil vapor monitoring interval and intercepts the current TSA groundwater level (approximately 102 ft bgs). Both initial and followup well sampling will be performed in each of the three new wells to assess repeatability and representativeness of findings. If elevated VOC groundwater concentrations are detected and sufficient water column is available, slug testing will be additionally performed to assess hydraulic conductivity as a potential indicator of VOC mobility.

The findings will be used to evaluate whether there remains a likely potential for VOC leakage or release to TSA groundwater in the vicinity of the MW-17 well cluster and will inform future mound area remedial investigative and design plans.

If elevated VOCs are present in soil, localized or perched groundwater, and/or soil vapor at depths above both the current and historical TSA water tables:

- There may be the potential for ongoing downward leakage and adverse impact to TSA groundwater.

If elevated VOCs are present in soil and soil vapor in the unsaturated zone underlying the historical TSA water table:

- There may be the potential for future TCE release to groundwater within the historically saturated zone.

4. Scope and Methods

This section describes methods that will be used during drilling, coring, sampling, logging, well construction, development, monitoring and sample analyses, slug testing, surveying, and waste management.

Borehole Drilling. Drilling will be performed by an Oregon-licensed and bonded well driller using a track-mounted rotosonic (sonic) drilling rig and continuous core sampling methods. All drilling and well installation methods will be conducted in accordance with Oregon Water Resource Department (OWRD) regulations or special standards approval, if needed.

Before drilling begins, underground utilities will be located, start cards will be obtained from the OWRD, and downhole drilling equipment will be decontaminated using high pressure or steam-cleaning methods. Decontamination water will be contained and transported to Cascade's off-site groundwater pre-treatment holding tank for air stripper treatment. Health and safety procedures will be reviewed with all field personnel and safety monitoring equipment will be calibrated for use in monitoring vapors within the breathing zone during drilling.

A summary of step-down drilling and sealing methods that will be used is bulleted below.

- Each well step-down borehole will be drilled to approximate 12 inch and 6 inch diameters. Temporary steel outer casings of similar diameters will be advanced behind the core bit to maintain open hole conditions.
- The 12 inch borehole and temporary steel casing will extend to the approximate top of the CU1 siltstone (SU1a) (approximately 20 ft bgs, per the MW-17ds log).
- An 6 inch diameter core barrel will then be used to advance the hole using 1 to 2 foot drill and core recovery intervals to locate the top of the CU1 claystone (SU1b).
- The 12 inch borehole and temporary casing will then be advanced approximately 1 foot below the top of the CU1 claystone and the borehole will be cleaned out using an 8 inch core barrel.

- The step-down seal will then be constructed by driving a permanent 8 inch steel casing one to two feet further into the CU1 claystone using rotosonic vibrations, for a total of 2 to 3 feet of permanent step-down casing penetration below the top of the claystone.
- If the CU1 claystone thickness is found to be 8 or more feet thick in the first well drilled, the step-down seal penetration length may be increased from 2 to 3 feet to no more than 5 feet for subsequent wells at this cluster location.
- The permanent 8 inch casing will be centered in the 12 inch hole using centralizers welded near the base and top of the casing.

- A high-solids bentonite-cement grout is selected for use, due to both its sealing and structural properties for maintaining the centered permanent steel casing position.
- The grout will be injected into the annular space between the 8 and 12 inch casings, extending from 1 foot below the top of the CU1 claystone upward through the TGA.
- The step-down seal grout will be injected through a tremie pipe set near the bottom of the annular space and will be lifted during grout emplacement, while kept below the top of the grout for continuous seal placement. The grout seal will be allowed to cure for 24 hours before step-down drilling proceeds.
- After curing is complete, 6 inch diameter equipment will be used to advance the hole to the targeted well installation depth.
- If the presence of wet conditions is not sufficiently evident in soil core samples to identify the wet or perched groundwater horizons targeted for well screen placement, the borehole may be purged dry using bailer or other low flow methods and allowed time for potential groundwater infiltration.

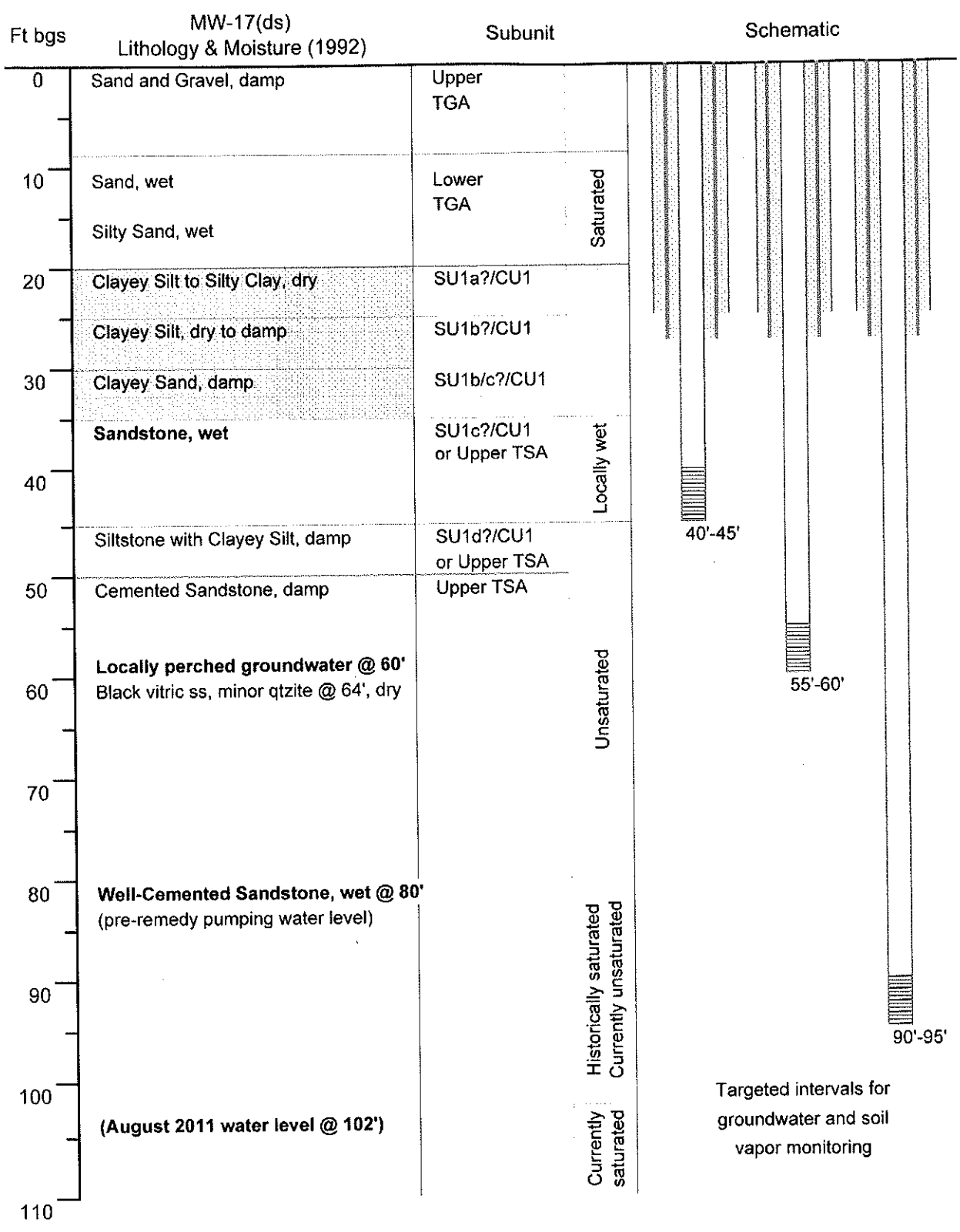

Figure 5
Schematic Well Cluster Profile
TSA Remedy – East Multnomah County

Y:\Prowell Environmental\Cascade\TSA 11 Drill Plan\Figure5.dwg 12/20/11