# Pall Corporation Site
# Dye Tracer Test 26-Week Summary
# November 2011

The following provides an update of the Pall Corporation dye tracer test to date. The 26-week schedule for the test was completed with the analysis of samples collected on May 19, 2011. The test was extended to September 22, 2011 because Eosine, which had been injected at the upgradient edge of the site, had not yet been detected in any of the monitoring points. Samples were collected on July 14, 2011, August 18, 2011 and September 22, 2011 during the extension.

## Background Analysis

Charcoal receptors were installed in each well involved in the dye tracer study on September 30, 2010 and collected on October 18, 2010. These samples were analyzed to establish a background concentration in the groundwater at each location of the two dyes injected.

During the dye tracer test, the presence of dye at a given sample location (i.e. a positive trace) is confirmed after two consecutive lab detections that are each at least 10 times the background concentration. If the concentration of dye in a well was non-detect during the background testing, a positive trace is confirmed by two consecutive detections of at least 10 times the lab detection limit. Lab results less than the 10 times factor are noted as "background". In some cases, a value is reported as "no peak identified", which is considered non-detect.



## Interference analysis

During collection of the background samples, groundwater samples were also collected from MW-4PI and MW-12D for matrix interference testing. This testing showed that the proposed dyes to be used, fluorescein and Eosine, did not degrade over time in the groundwater and that there were no serious interference problems that would preclude the use of fluorescein and Eosine, although Eosine eluted from the site groundwater at about half the concentration as the distilled water elution.

## Dye Injection

Dye was injected at the two locations, MW-4PD and MW-6PD, on November 16 and 17, 2010. Fifteen pounds of fluorescein was injected into MW-4PD followed by 325 gallons of clean water. Thirty-five pounds of Eosine was injected into MW-6PD followed by 325 gallons of clean water. Refer to the attached figure.

### Dye Sampling and Analysis

Charcoal dye receptors were deployed in monitoring wells downgradient of the dye injection points. At 3-week intervals CDM collected the receptors and deployed new receptors. The collected receptors were shipped to the Crawford Hydrology Laboratory for analysis of the charcoal eluent by spectrofluorophotometer. After May 19, the residence time for the receptors was increased to five weeks in order to further extend the tracer test duration.

The use of charcoal dye receptors is advantageous over the analysis of aqueous grab samples because it allows for continuous monitoring. This reduces the potential for false negatives, which

could occur by dye moving past a monitoring point between sampling events. However, aqueous samples were also collected during each sampling event, and kept on hold for contingency purposes.

**Dye Tracer Analytical Results**

The following discussion pertains to charcoal eluent analysis, unless otherwise specified.

Fluorescein has been confirmed at eight monitoring wells with two or more consecutive detections, each above 10 times the background level or the detection limit if background was non-detect. The spatial and temporal patterns indicate that fluorescein migrated north-northwesterly with the groundwater gradient in the deep zone, and also entered the intermediate zone in close proximity to the injection location, where it migrated in a similar direction. A summary of the fluorescein detections, moving progressively downgradient (north-northwest) from the injection point is provided:

- The first of two consecutive fluorescein detections at MW-4PI was the sample collected on February 23, 2011; thus fluorescein migrated from the deep zone, where it was injected at MW-4PD, to the intermediate zone in approximately 3 months (the February 7, 2011 sample was non-detect for fluorescein). Fluorescein had moved past MW-4PI by March 16, 2011, as the charcoal receptor deployed between March 16 and April 8, 2011 was non-detect.

- Fluorescein appeared at MW-12PI and MW-12PD, about 100 feet north-northwest of the injection point, in the samples collected on February 23, 2011. Fluorescein had moved past MW-12PI by August 18. Fluorescein had moved past the deep well by July 14, 2011. The fluorescein concentration in the intermediate well was about equal to or greater than those in the deep well.

- Confirmed flourescein appeared on April 8, 2011 at MW-2AI and MW-2AD, approximately 300 north-northwest of the injection point. Fluorescein moved past these wells by April 27, 2011. The concentrations in the intermediate well were less than those in the deep well (about one-third to three-fourths less), consistent with dilution as the dye moved vertically.

The monitoring well locations along a line just north of the aforementioned wells exhibited fluorescein in the deep zone, MW-5PD, MW-10PD and MW-11PD, but not in the intermediate zone. These wells are aligned more northerly with the injection point. The absence of confirmed fluorescein along this alignment suggests it is slightly off the groundwater flow path and/or better hydraulic separation exists between the two depth zones in this area.

Moving progressively downgradient from the injection point along this alignment:

- Fluorescein was first confirmed at MW-11PD, about 150 feet from the injection point, in the sample collected on March 16, 2011 and had moved past the well by August 18, 2011.

- Fluorescein was first confirmed at MW-5PD, about 220 feet from the injection point, in the sample collected on February 23, and had moved past this well by April 27, 2011.

- Fluorescein was first confirmed at MW-10PD, about 220 feet from the injection point, in the sample collected on April 8, and had moved past this well by April 27, 2011.

Previously, a non-confirmed single "hit" of fluorescein was detected at downgradient well MW-2AI in the January 19, 2011 sample, followed by a low detection in February that was less than the 10-times background criteria. This did not constitute a positive dye trace, and CDM was surprised to see fluorescein so soon at MW-2AI, which is the furthest downgradient well from the injection point, because it suggested that the fluorescein was bypassing the other wells. It now appears that the earlier, unconfirmed "hits" should be not be considered positive dye traces, and that fluorescein first arrived at MW-2AI in April 2011.

Fluorescein has also been confirmed at MW-13PD, beginning on July 14, 2011 and persisting through the last sample event. However, this location is upgradient of the fluorescein injection location. The reported concentrations were low, and a background condition of a substance with a similar wavelength to fluorescein was found in the background sample and most of the previous samples collected at this well. Therefore, it is possible that the fluorescein detected at MW-13D is related to the background substance. Fluorescein is not believed to have migrated from MW-4PD to MW-13PD, and these detections are not shown on the attached figure.

Eosine has been confirmed in only one well aside from where it was injected. This Eosine trace was first detected at MW-6PI on August 18, 2011, nine months after dye injection. The concentration detected on September 22, 2011, the last sample collected, had increased an order of magnitude. MW-6PI is the intermediate well co-located with the deep will in which Eosine was injected. Eosine was not confirmed in any well downgradient of this location.

**Summary and Recommendations**

Fluorescein was traced downgradient of the injection points in both the deep and intermediate zones. Eosine was detected in the intermediate zone at the location where it was injected into the deep zone. Therefore, the data indicate that there is a component of contaminant migration from the deep groundwater zone to the intermediate zone, and remediation of the intermediate zone could be subject to recontamination. This connection between the deep and intermediate groundwater zones was also indicated during the short-term aquifer testing. Therefore, CDM recommends a coordinated effort on the remedial designs for both the intermediate (OU-1) and deep (OU-2) groundwater units. This coordinated effort would ensure that both OUs were remediated simultaneously without recontaminating the intermediate zone.