# Use of Fluorescent Tracer Particles in the Lower Duwamish Waterway

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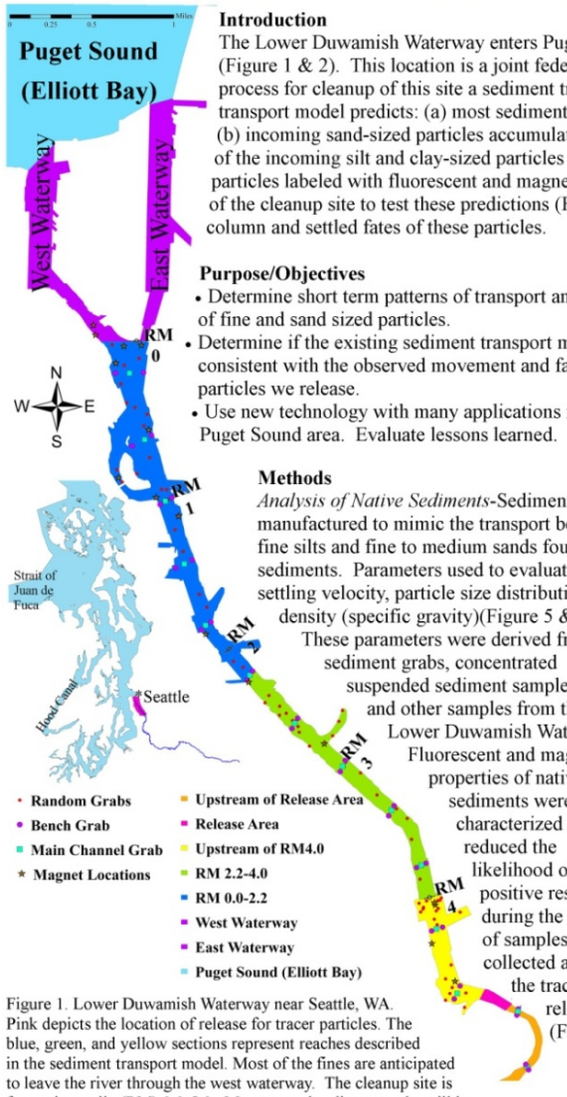


Figure 1. Lower Duwamish Waterway near Seattle, WA. Pink depicts the location of release for tracer particles. The blue, green, and yellow sections represent reaches described in the sediment transport model. Most of the fines are anticipated to leave the river through the west waterway. The cleanup site is from river mile (RM) 0.0-5.0. Magnets and sediment grabs will be used to recover tracer particles after release.

**Introduction**

The Lower Duwamish Waterway enters Puget Sound (Elliott Bay) just south of Seattle, WA (Figure 1 & 2). This location is a joint federal and state cleanup site. During the evaluation process for cleanup of this site a sediment transport model was developed. The sediment transport model predicts: (a) most sediment entering the cleanup site comes from upstream, (b) incoming sand-sized particles accumulate within the site, and (c) approximately one-half of the incoming silt and clay-sized particles (fines) pass through the site[1]. We will release particles labeled with fluorescent and magnetic properties (tracer particles) at the upper boundary of the cleanup site to test these predictions (Figures 3 & 4). We are interested in both water column and settled fates of these particles.

**Purpose/Objectives**

- Determine short term patterns of transport and deposition of fine and sand sized particles.
- Determine if the existing sediment transport model is consistent with the observed movement and fate of particles we release.
- Use new technology with many applications in the Puget Sound area. Evaluate lessons learned.

Figure 2. Lower Duwamish Waterway. Both sides of the waterway are industrial. Mt. Rainer can be seen in the distance.

**Methods**

*Analysis of Native Sediments*-Sediment tracers were manufactured to mimic the transport behavior of fine silts and fine to medium sands found in native sediments. Parameters used to evaluate this include settling velocity, particle size distribution, and density (specific gravity)(Figure 5 & 6). These parameters were derived from sediment grabs, concentrated suspended sediment samples, and other samples from the Lower Duwamish Waterway. Fluorescent and magnetic properties of native sediments were characterized to reduced the likelihood of false positive results during the analysis of samples collected after the tracer is released (Figure 7).

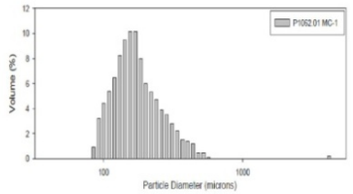


Figure 5. Sand sized particle distribution of a native sediment using laser diffraction[2]

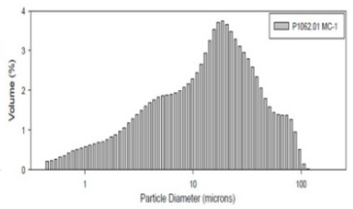


Figure 6. Silt sized particle distribution of a native sediment using laser diffraction[2]

*Tracer Specifications*

Development of final specifications for tracer particles relied on parameters derived from the analysis of Lower Duwamish Waterway sediments. Tracers were manufactured in two batches having different colors and characteristics (Table 1). The different colors will aid in the analysis of recovered tracers, allowing fines and sands to be easily distinguished.

Table 1. Final specifications describe tracers representative of the Lower Duwamish Waterway sediments. Two colors were required to determine different transport and deposition patterns of fine versus sand sized particles .

| | Fluorescent Color | Para-Magnetic ? | Density ($kgm^{-3}$) | Median Settling Velocity ($mms^{-1}$) | Modal Size (µm) | Size Range (µm) |
|---|---|---|---|---|---|---|
| Fines | | | | | | |
| Specifications | Yellow-Green | Yes | 1200 | 0.15 | 45 | 30-60 |
| Manufactured | Yellow-Green | Yes | 1210 | Data Not Available | 45 | 22-60 |
| Sands | | | | | | |
| Specifications | Red | Yes | 2650 | 13 | 146 | 60-250 |
| Manufactured | Red | Yes | 2560 | Data Not Available | 134 | 52-309 |

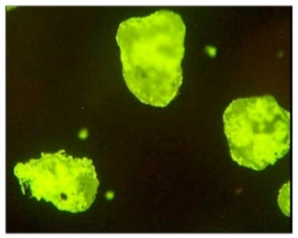

Figure 3. Microscopic view of tracer particles.[2]


Figure 4. Tracer particles in a sediment matrix subjected to fluorescent light.[2]

Figure 7. Microphotograph of natural magnetic material from bedded sediments collected in the Duwamish River. The largest grain in the center is 120µm.[2]

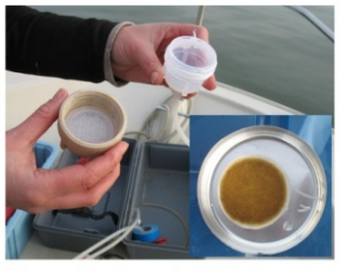

Figure 8. Sampling equipment used to recover tracers, two halves of an enclosed filter holder and a 1.6µm pore size filter after filtration in the Lower Duwamish Waterway.

*Release of Particles:* To eliminate the effects of any surface charge on the particles which may cause them to 'float' on the surface of the water temporarily, the material will be wetted thoroughly prior to release. Release of tracers into the Lower Duwamish Waterway will occur during a period of higher daily mean flows and during the daily maximum flow (ebb tide). These conditions explore the fate of fine and sand particles during high-flow conditions when most of the annual sediment loading is predicted to occur.

Tracers will be released:

- From a boat located near the southern boundary of the Lower Duwamish Waterway cleanup site (river mile 4.6).
- Below the waters surface.
- At a concentration that dilutes to within 50% of the *in-situ* total suspended solids measured approximately 0.10 miles downstream.

*In-situ* particle size analyzer field measurements, total suspended solids discrete samples, and filtered water samples collected directly downstream of the release will be used to evaluate the initial dilution.

*Tracer Recovery:* During release, filtered water column samples will be collected throughout the waterway with emphasis near the west waterway, river mile 0.0 (Figure 8). Random grab sampling stations represent the receiving environment such that mass transport and fate of tracers can be estimated. Subjective grab sampling locations will be used to address predicted settling zones and provide a longitudinal profile of the waterway. Random and subjective grab recovery efforts will occur one week, one month, and two months after release (Figure 8). Tracers will also be recovered using magnets mounted in the river for up to one month after release (Figure 10 & 11).

*Tracer Analysis:* Tracer analysis will be based on a combination of tracer dry mass quantification supplemented by image analysis. The dry mass of fluorescent tracers will be measured in each water and sediment sample (and passive magnet samples), as well as quality control samples if there is sufficient tracer in the sample. If only small quantities of tracer or no tracer is found, samples will be analyzed using imaging techniques. Because two colors are being used to differentiate the fine and coarse size fractions, image analysis on recovered samples will also be necessary to determine the proportion of sands vs. fines. Quality control samples will consist of blanks, replicates, and matrix spikes. A sub-set of samples will be analyzed to determine particle size distribution. Laser diffraction analysis will be used if sufficient amounts of tracer are recovered. Otherwise particle sizes will be determined using microscopy.

**Next Steps**

- Release of particles will occur during February 2009.
- Analysis of all samples is scheduled to be completed by mid-May 2009.
- Final report is scheduled to be completed during the summer of 2009. It will be available on the web at: www.ecy.wa.gov/biblio/eap.html

**References**

[1]Lower Duwamish Waterway Group, 2008. Lower Duwamish Waterway Sediment Transport Modeling Report, pp. 253.
[2]Photos courtesy of Kevin Black, Partrac Ltd.

Figure 9. Sediment grab using a single VanVeen type sampler.

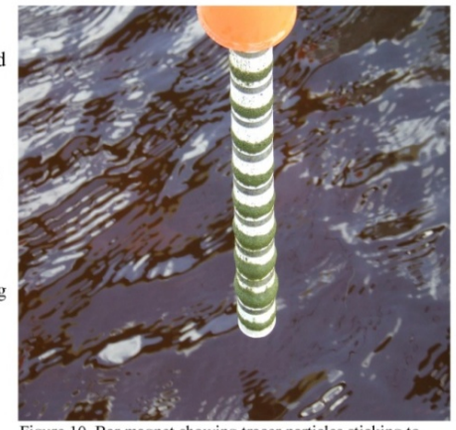

Figure 10. Bar magnet showing tracer particles sticking to the magnetic poles.[2]

Figure 11. Magnets mounted on pilings in the Lower Duwamish Waterway. These magnets will collect tracer particles as they drift by.

**Publication Information**
Washington State Department of Ecology, Publication No. 09-03-029.
www.ecy.wa.gov/biblio/0903029.html. June 2009.