APUSS

Assessing Infiltration and Exfiltration on the Performance of Urban Sewer Systems

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DELIVERABLE 2.3

STANDARD PROTOCOLS FOR ASSESSING THE EFFECT OF REAL SEWER SEDIMENTS AND FLOW CONDITIONS ON TRACERS

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This interim report provides outline information on progress towards testing and establishing standard protocols and procedures for the evaluation of *in-situ* interactions between live wastewater sewer sediments and tracers. The work described herein represents an interim statement pending a more detailed and fuller report to be completed in fulfillment of the required 24 month deliverable (Deliverable D2.3 in original Description of Work, 26 June 2000). Progress in achieving the final objectives has been limited due to problems resulting from the loss of research personnel due to illness and protracted negotiations with UK water authorities on the location, installation and funding of a field test rig.

1.1 In-Sewer Tests

1.1 Initial tests of a commercial fluorescent probe (a Turner design SCUFA) to monitor the natural *in-situ* variations in fluorescence and turbidity of a live wastewater sewer were undertaken in a small 160mm pipe serving a section of the Middlesex University campus. Figure 1 shows the relationship between fluorescence and turbidity variations recorded within the sewer pipe over a 4 hour period which suggests that, providing turbidity is taken into account, Rhodamine WT might be used as a tracer even in the presence of high concentrations of organic-rich solids. The sewer pipe is subject to very rapid changes in both water level and quality as indicated in the figure with turbidity fluctuating rapidly over a range of 100 to 1000 NTU. This reflects the random episodic evacuation of individual toilet units and the rapid flushing of faeces down the sewer pipe. 24 hour monitoring revealed minor overnight fluorescent peaks which are probably due to the automatic toilet flushing mechanism rather than to any inherent sewer infiltration waters. The investigation demonstrated that a linear relationship exists between turbidity and fluorescence with the fluorescent response signal (Figure 2) showing a good sensitivity to an upstream tracer dosing injection (20ml of 200 mg/l Rhodamine WT). The experiment also illustrates the potential of the fluorescent probe to identify individual sediment events (through the turbidity variations) in real time.

1.2 As described in Annexe 2 of the WP2 report to the 3rd Management Report (July 2002), further preliminary testing has been conducted to assess the practicality of using the Rhodamine WT dye for *in-situ*, real time assessment of live wastewater sewer flows. The instrument was tested over a 24 hour period in the inlet flow (Figure 3) of a major sewage treatment works serving the town of Reading in S E England (population 150,000). As shown in Figure 4, diurnal and generally parallel trends are evident between fluorescence and turbidity with suppressed readings for both parameters occurring between 21.00 and 07.00 during minimum night-time flow periods. The tests confirm the robustness of the method and the instrumental reproducibility of field data noted from the initial experiments in the small sewer pipe. The interaction of Rhodamine WT with settled samples of inlet sewage was tested in the laboratory at concentrations of 50ppb, 100ppb and 20ppb, with all three solutions demonstrating similar adsorption trends. A maximum fluorescent signal reduction of 50%, due to sediment adsorption, was observed and is consistent with the findings reported for the use of this tracer in aquifer studies (Vasudevan *et* *al*., 2001). The noted sediment uptake pattern can be explained by particle coagulation processes which occur during the experimental stirring procedure and which results in the release of adsorbed dye back into solution as the available adsorptive surface area of the heterogeneous suspended particles decreases.

1.3 Laboratory adsorption tests recently conducted on both raw and settled sewage taken from Manor Farm STW, Reading and Deephams STW, Edmonton, N E London have confirmed the consistent adsorptive behaviour of Rhodamine WT in the presence of organic sewer sediments (see Section 4b, second annual report for WP2 for period 01/2002 - 12/2002). Thus whilst Rhodamine WT provides a safe, direct on-line, real time measurement method having high sensitivity and response rates with a low detection limit, it's adsorptive characteristics do not make it the ideal tracer for future exfiltration work.

2. Field Test Rig

2.1 Negotiations have taken place with Thames Water and Scottish Water to install a test rig to test the effectiveness and efficiency of tracers to monitor and quantify live wastewater flows in a major sewer and to evaluate the adsorptive properties of real sewer sediment under operational field conditions. A contract of £15,000 has now been agreed (December 2002) with these funders to sponsor the location and installation of a test rig on the site of a screening works at Riverside, Dundee in Scotland. The work will be undertaken in collaboration with the Urban Wastewater Technology Centre, Abertay University. Figure 5 shows the site which is adjacent to the River Tay with the proposed location of the 5m test rig over the storm overflow chamber. This location offers the additional advantage of a 830m sewer run to a downstream inspection chamber which can be utilized for full scale tracer testing.

2.2 The general layout of the rig is illustrated in Figure 6 and will consist of a 150mm diameter pipe with 3 boxes placed at 1.5m intervals to simulate and test sewer joint openings with free exfiltration to trench backfill and underlying soil layer. This configuration will allow three basic gap geometries (10mm hole, 0.5 diameter horizontal and 0.5 diameter vertical) to be tested for 1mm and 2mm gap sizes in single runs. It is proposed these initial test runs will investigate exfiltration rates and patterns with only the gravel (and gravel/sand) trench backfill in place and for varying flow rates ($Q_{10} – Q_{50}$) and hydraulic head. This will enable comparisons to be made with reported results already obtained from the experimental clean water rig. These initial test runs will then be followed by a series of tracer tests utilizing the *in-situ* fluorescent probe (for Rhodamine WT detection) and a purposely designed specific ion electrode system for lithium detection. A final series of test runs will be undertaken with the substrate layer in place under the trench backfill and for both dry and wet soil conditions. It is proposed to convene a Workshop to deliver and discuss results and potential operational implications with the water authority end-user funders. This will offer a forum for the identification of further

R&D priorities for both the Riverside test rig and in the development of an on-line "live sewer" test facility.

References

Vasudevan, D, Fimmen, R.L and Fransisco, A.B. 2001 Tracer-grade Rhodamine WT: Structure of constituent isomers and their sorption behaviour. *Environ.Sci. Tech*., 35, 4089-4096.

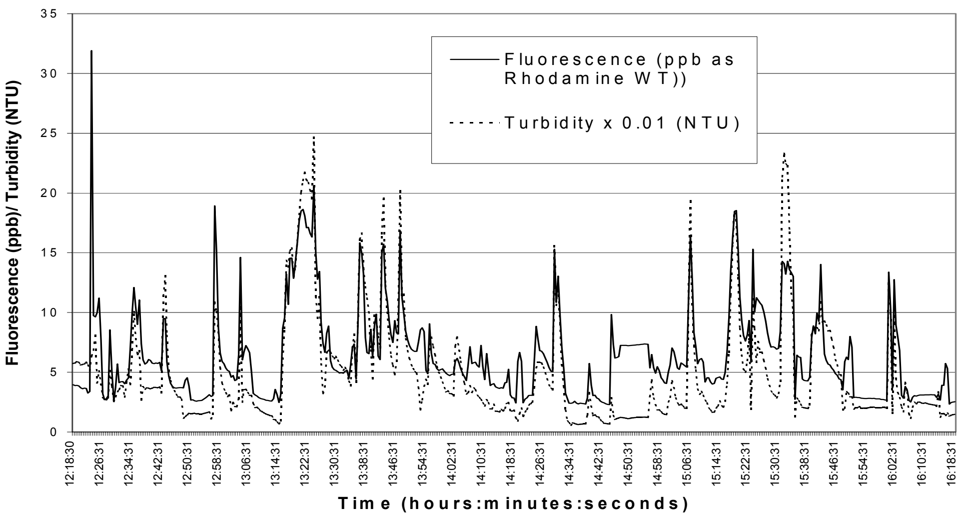

Figure 1. Temporal variation in fluorescence and turbidity within a small foul sewer.

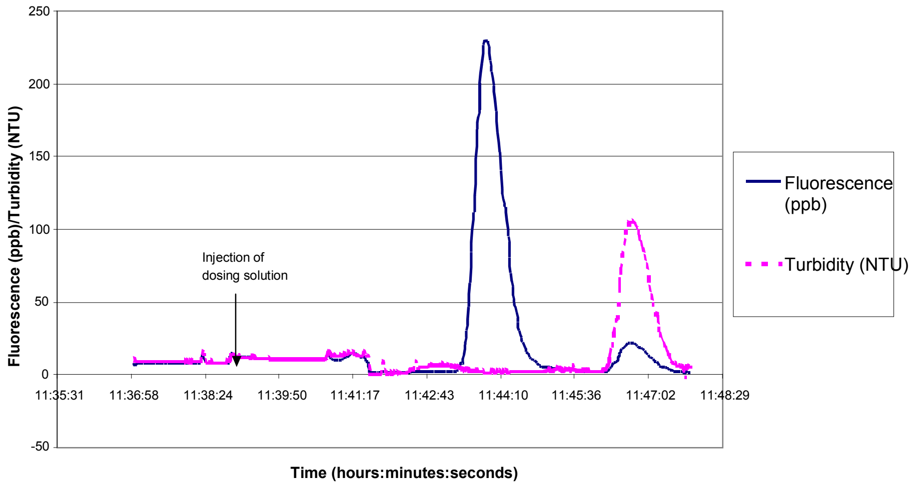

Figure 2. Downstream sewer monitoring of fluorescence and turbidity after dosing with 20ml of 200 mg/l of Rhodamine WT

Figure 3. Monitoring inlet flows at Manor Farm STW, Reading

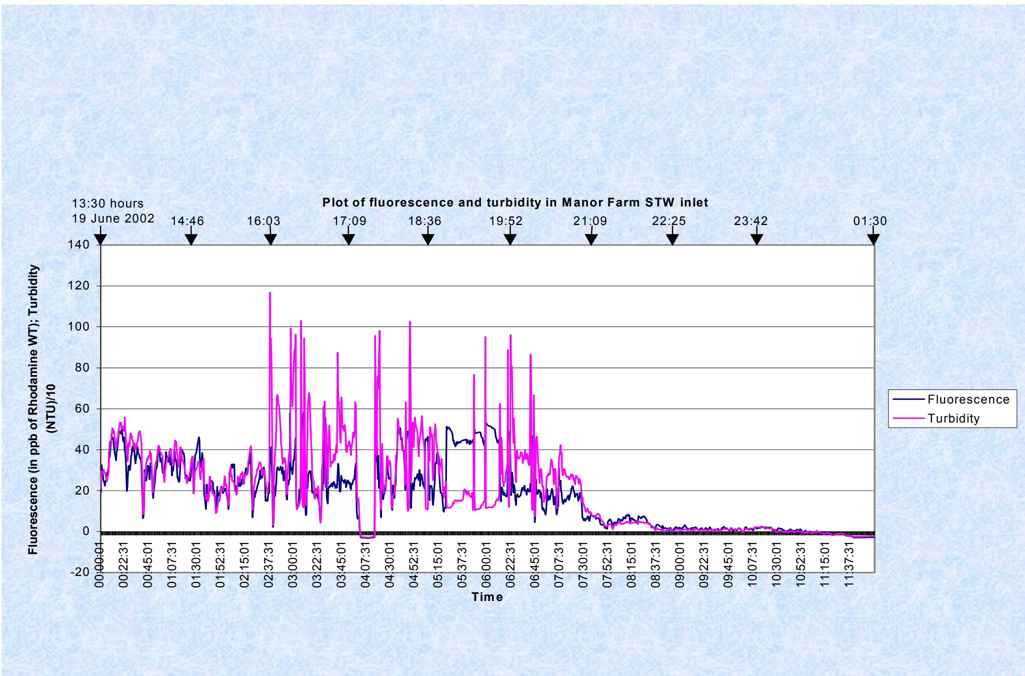

Figure 4. Temporal variation in fluorescence and turbidity monitored in raw sewage entering Manor Farm STW, Reading

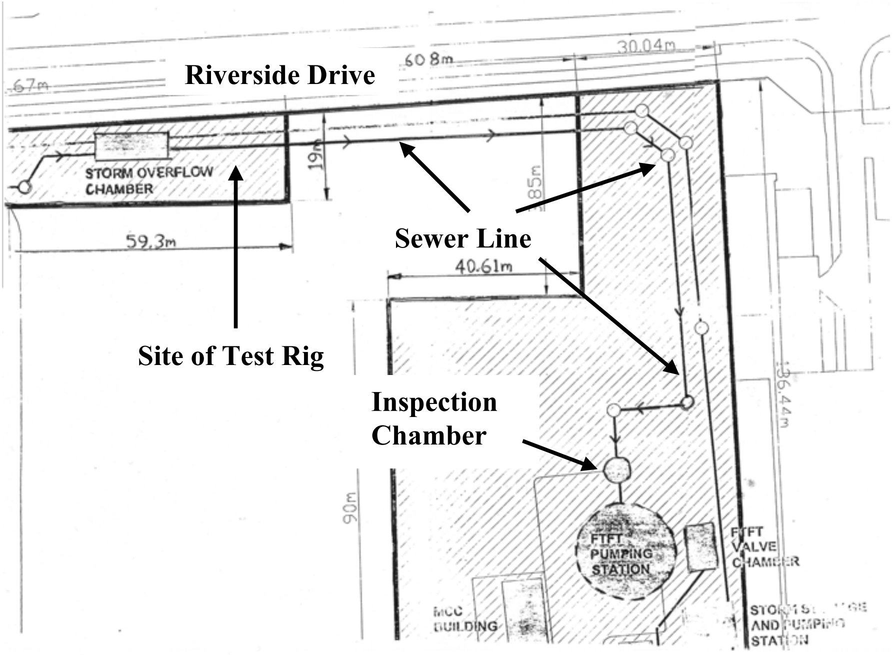

Figure 5. Riverside Drive site, Dundee

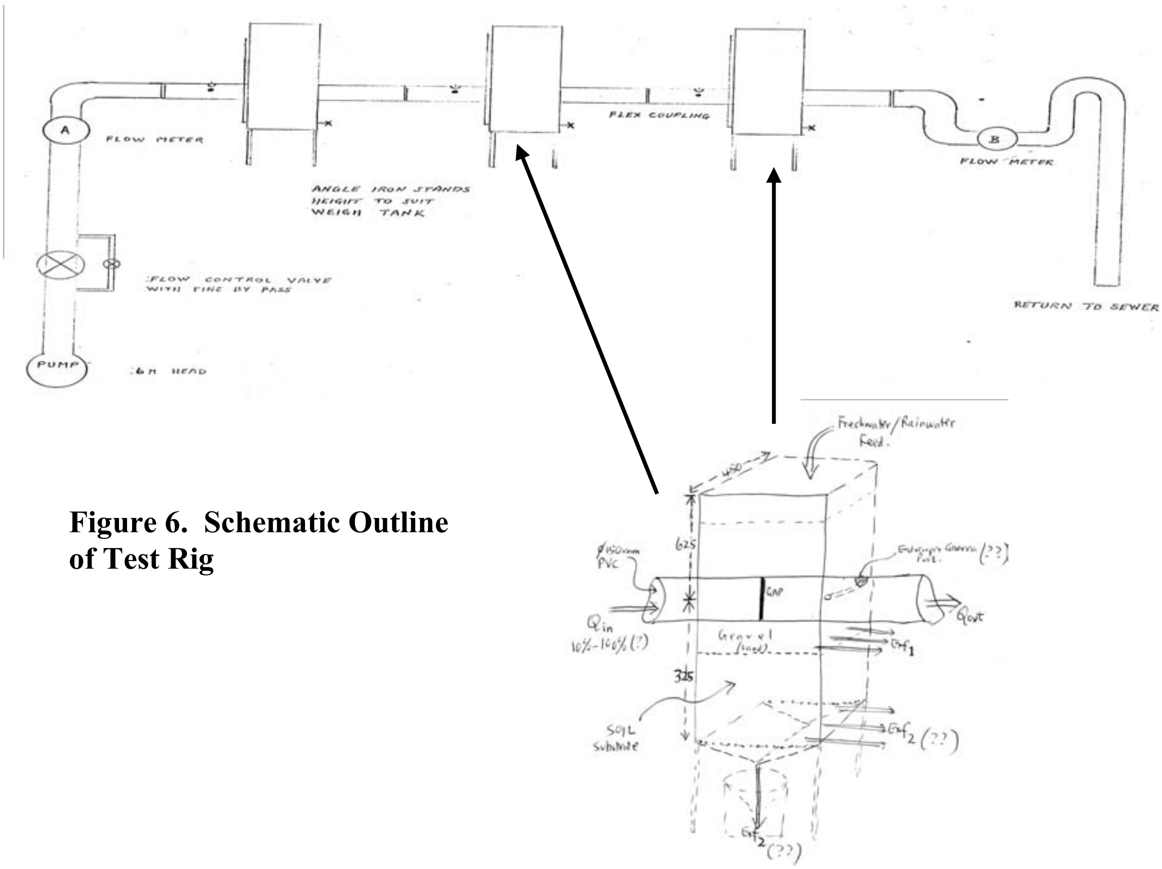

Figure 6. Schematic Outline of Test Rig