Proposal to Implement a Dye Tracer Test near Malad Gorge

By Neal Farmer IDWR

Background and Objective:

Numerous groundwater tracer tests have been performed south of the Malad Gorge State Park to trace groundwater flow paths and determine other aquifer characteristics since year 2008. This test is an addition to the previous tests and builds on the body of the knowledge gained to refine methods and delineate convergent flow using a domestic supply well located east of the Gorge (Figure 1) for dye release. The owner has been contacted, informed of the details of the test and is agreeable to allowing dye tracing to be performed using the well. Rhodamine WT will be used with charcoal packets placed at monitoring locations along with two "C3" instruments and a "SCUFA" to record dye concentrations. The use of RWT will be brief and infrequent as it is only expected to implement this test once if the results are complete. If a 2nd test is needed, there will be several months of time elapsed between tests to allow for dye residuals to reduce to essentially non-detectable levels.

Various components go into the design of a tracer test. For the previous tracer test, the following elements were considered and evaluated: the conceptual design, down gradient receptors such as humans, aquaculture industry and endangered species, transient hydrologic barriers such as canal recharge, selection of initial mass of tracer or its concentration, observation wells, sampling schedule and locations, and monitoring. Safety of Rhodamine WT is documented from scientific studies and it is EPA approved for use in public drinking water supplies and notes it as "non-toxic" (see reference sources). The dye conforms to the ANSI/NSF Standard 60 for potable water as set forth by the EPA in the Clean Water Act. The dye is biodegradable and photodegradable with decomposition products of carbon dioxide, water and an infinitesimal about of sodium.

Location and Site Conditions

The legal location of the well is Range 14E, Township 6S, Section 31, NW ¼ of the NW ¼ Gooding County (Figure 1). The well targeted for dye release is shown in Figure 1 as the "Conklin" well. As with previous tests, the pump will be turned off for 24 hours minimum after dye release which is also agreeable to the home owner. At least 20 sample locations will be established in the Gorge are shown with the labels MG # at points of spring discharge. All of these sites will be monitored with charcoal packets and two 'C3' instruments and one 'SCUFA' instrument will be deployed to record hourly concentration data. It is about 3,700 feet between the well and the springs in the Gorge where dye is expected to daylight and there are no wells directly in between the dye release well and these springs. The closest domestic well to the east is 1,800 feet up-gradient and the domestic wells to the south are across and up gradient too. The Malad Gorge Picnic area well may intercept the dye cloud and it will be monitored closely for dye with both charcoal packet and water samples collected daily during the test and evaluated for dye.

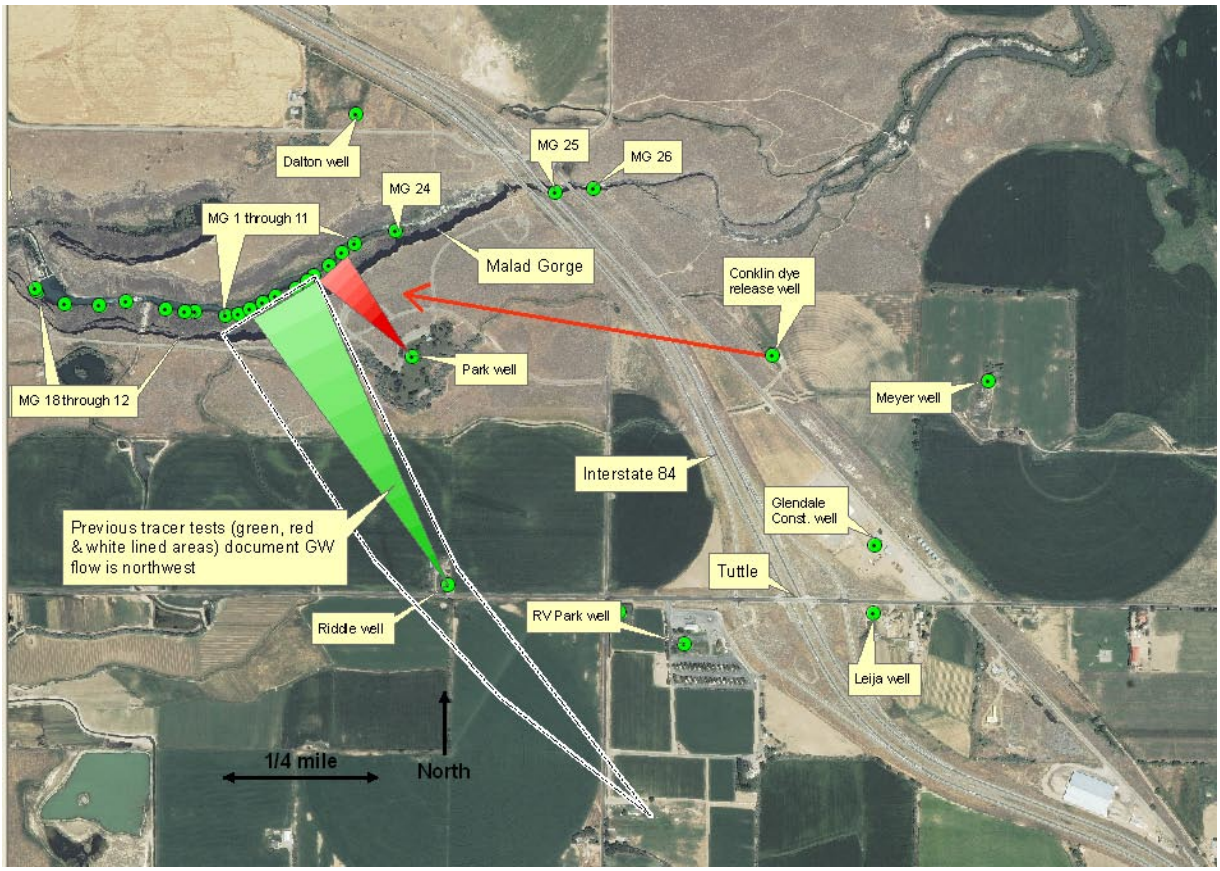

Figure 1. Location map for the RWT groundwater tracer test east of the Malad Gorge State Park using the 'Conklin' well. All sites with green circles will be monitored during the test. The red line is the anticipated groundwater flow direction. The red, green and white triangular shaped areas are locations and distribution of previous dye tests.

Geologic Conditions and Subsurface Conceptual Flow Model

Water prefers to flow down gradient and along paths of least resistance (high hydraulic conductivity) and the highest flows are expected to be through basalt contact zones with possible 'conduit' type of flow path characteristics or pillow lava features. A pillow lava layer up to 30 feet thick is exposed in outcrop in the base of the Gorge with spring water discharging from it. Approximate horizontal groundwater flow velocities are inferred from a previous tracer test in the Malad Gorge State Park well. The total project time period is expected to last about 6 weeks from start to finish but, the start date is undefined and contingent upon the schedule of the owner and may be several months before it is convenient for them to start the test.

The well drilling report (appendix) shows open borehole (6-inch) with no casing below 21 feet and there are cinders/broken basalt within the saturated zone of the aquifer from 145-200 feet. The water level in the well on January 7, 2011 was 118.40 feet below land surface but the dye will be released at the cinder/broken basalt level from 145-200. Figure 2 shows the conceptual 2-D model for conditions and dye transport to the springs and river.

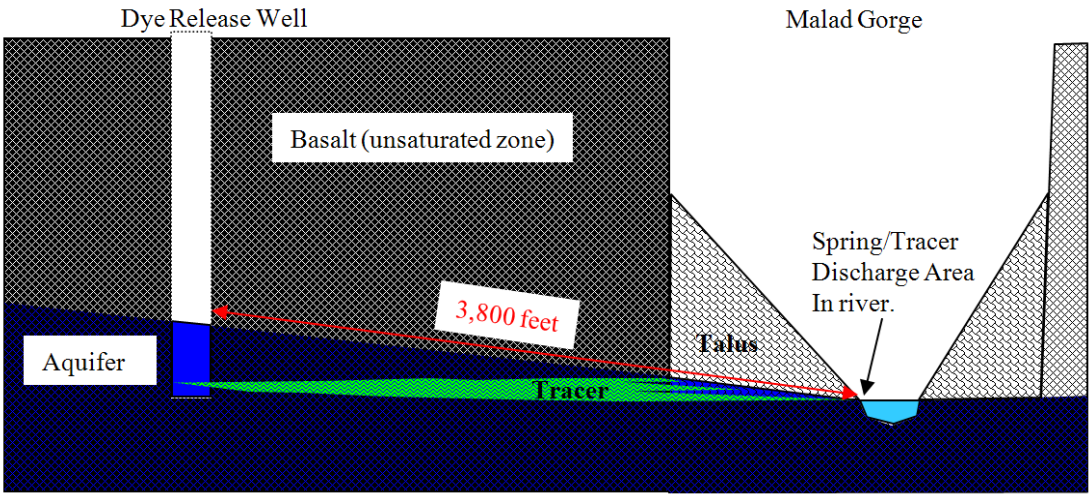

Figure 3. Conceptual 2-D cross section model of the tracer test from the Conklin well to Malad Gorge.

Implementation Plan

Four pounds of Rhodamine WT dye mixed in 8 gallons of water from this well will be released into the Conklin well. The well will be turned off for at least 24 hours after dye release. After the dye release is finished (about 24 hours later) the Conklin well will be tested for bacteria and disinfected if necessary. It will also be checked for residual of dye and purged until the concentration is below 0.8 ppb if necessary (see Technical Data FWT Red liquid or http://www.brightdyes.com/technical/FWTRed.html). None of the dye tracer tests so far have had any detectable amounts of dye residual in the well after about 24 to 48 hours after release

which documents how fast the water is carrying the dye out of the well. Charcoal packets and calibrated instruments will be deployed prior to dye release. Water samples will be collected from the wells and springs prior to dye release. The Malad Gorge picnic area well will be sampled daily and checked for dye. As with previous tests, once the dye enters the river it should be below detection limits.

Rhodamine WT is certified by ANSI/NSF for Standard 60 potable water and approved by the EPA as noted by a copy of the certification located in the appendix for use in surface water streams up to 100 ppb. There are no public drinking water intakes in the Malad Gorge River or in the Snake River in this general area. The test will be designed with the goal to keep the concentration of dye reaching wells and the springs far below the maximum Rhodamine WT concentration of 100 ppb from the springs. Previous RWT tests have provide documented case examples to support the amount and concentrations of RWT at this scale and geologic environment.

IDWR staff will analyze water samples and charcoal packets collected from the wells and springs in the lab with a calibrated lab fluorometer model TD-700 made by Turner Designs and calibrated SCUFA and C3 instruments onsite. All water samples will be retained and stored in a refrigerator until the test is completed. QA/QC will be attained by calibrating both field and lab instruments with standards according to the manufactures guidelines and USGS protocol (Wilson et al, 1986). Data analysis and report writing will be performed at the end of the test discussing and describing the results and recommendations for future actions. Copies will be made available.

FLUOROMETRIC FACTS

Bulletin No. 104 Fluorescent
Tracer Dyes

Rhodamine WT has been approved as a tracer dye in potable water in the United States (1).

Rhodamine WT is related to rhodamine B, a tracer in common use in the 1960s. It was developed to overcome a disadvantage of rhodamine B, absorption on suspended sediment. The same modification was expected to reduce toxicity, and limited testing bore this out.

Rhodamine WT was an immediate success as a tracer in marine systems and in wastewater. While it was also used in potable water, such use was occasionally forbidden on the grounds that it did not have formal Federal approval for such use. Rhodamine WT is now approved for such use. A brief history follows.

While the EPA has sole responsibility for identifying those substances which may be used a tracers (2), the Food and Drug Administration (FDA) does issue policy statements. The FDA did issue such a policy statement on 22 April 1966 concerning rhodamine B (3). A temporary tolerance limit for ingestion of rhodamine B was set at 0.75 mg per day. Based on normally expensed water consumption, the tolerance would not be exceeded unless the concentration approaches 370 parts per billion (PPB). Noting that 30 PPB may be detected visually in a glass of water, and 10 PPB is visible in larger volume such as a clear reservoir, the FDA pointed out that if the dye is not visible, the tolerance would not be exceeded. The USGS, a large user of fluorescent dye tracers, directed that the concentration should not exceed 10 PPB at the intake of a water supply (4). The visual and instrumental detectability of rhodamine WT, based on active ingredient, is about the same as rhodamine B (rhodamine WT is supplied as a 20% aqueous solution).

Ten parts per billion may not sound like much to the uninitiated, but it is a thousand times the limit of detectability guaranteed by Turner Designs on its Model 10 Series Fluorometers (5). Background fluorescence caused by fluorescent materials in the water being studied usually limits detectability. But even so, measurements can be made to 0.1 part per billion of rhodamine WT (active ingredient), in raw sewage!

On April 10, 1980, Dr. Joseph A. Cotruvo of the U.S. EPA issued a memo stating that the EPA considers rhodamine WT to be equivalent to rhodamine B (1). More recently, the following policy letter was sent to Crompton and Knowles:

United States Environmental Protection Agency
Washington, D.C. 20460
Aug 2 1988
Office of Water Ms. Janice Warnquist Chemical Safety Manager
Crompton and Knowles Corporation

P.O. Box 341 (500 Pear Street)
Reading, Pennsylvania 19603

Dear Ms. Warnquist:

The Criteria and Standards Division (Office of Drinking Water) has reviewed the available data on chemistry and toxicity of Rhodamine dyes. We would not anticipate any adverse health effects resulting from the use of Rhodamine WT as a fluorescent tracer in water flow studies when used with the following guidelines.

-A maximum concentration of 100 micrograms/liter Rhodamine WT is recommended for addition to raw water in hydrological studies involving surface and ground waters.

-Dye concentration should be limited to 10 micrograms/liter in raw water when used as a tracer in or around drinking water intakes.

-Concentration in drinking water should not exceed 0.1 micrograms/liter. Studies which result in actual human exposure to the dye via drinking water must be brief and infrequent. This level is not acceptable for chronic human exposure.

-In all of the above cases, the actual concentration used should not exceed the amount required for reasonably certain detection of the dye as required to accomplish the intended purpose of the study.

The Criteria and Standards Division recommends that Rhodamine B not be used as a tracer dye in water flow studies.

This advisory supersedes all earlier advisories issued by EPA on the use of fluorescent dyes as tracers in water flow studies. This advisory is granted on a temporary basis only.

EPA is terminating its voluntary additives advisory program as announced in the Federal Register (53 FR, 25586, July 7, 1988). A copy of the Federal Register Notice is enclosed for your convenience. All EPA advisory opinions issued within the framework of the additives program will expire on April 7, 1990.

Our opinion concerning the safety of this tracer dye does not constitute an endorsement, nor does it relate to its effectiveness for the intended use. If this letter is to be used in any way, we require it to be quoted in its entirety.

Sincerely,

Arthur H. Perler, Chief Science
and Technology Branch Criteria
and Standards Division

Enclosure

REFERENCES

1. Cotruvo, J. A., RHODAMINE WT AND B, Memo to P. J. Traina, dated April 10, 1980

2. Letter from A. D. Laumback, FDA, to George Turner, dated 7 June 1977

3. POLICY STATEMENT ON USE OF RHODAMINE B DYE AS A TRACER IN WATER FLOW STUDIES, Department of Health, Education and Welfare, dated 22 April 1966

4. Kilpatrick, F. A., DOSAGE REQUIREMENTS FOR SLUG INJECTIONS OF RHODAMINE BA AND WT DYES, U. S. Geological Survey, Prof. Pater 700-B, B250-253 (1970)

5. FIELD FLUOROMETRY, Monograph available at no charge from Turner Designs

TURNER DESIGNS
845 W.Maude Ave. Telephone 408-749-0994
Sunnyvale, CA 94085 Toll Free 877-316-8049
www.turnerdesigns.com Fax 408-749-0998

Biological Considerations

Fluorescein and Rhodamine WT have very low toxicity, biologically degrades and photo degrades when exposed to sun light into carbon dioxide, water and an infinitesimal about of sodium. A literature search (see appendix) has been made to ensure that biological risks to humans (Field et al, 1995, Smart 1984), human food sources, and aquatic species such as fish, snails and Daphnia are taken into consideration for the test design and there is no known adverse effects anticipated given the project design. Dye tracing has been performed at locations with endangered species (snails and shellfish), human food sources (trout farms), and salmon spawning beds for over half a century with the approval of the U.S. Fish and Wildlife Service, EPA, FDA, state agencies and other private and non-profit organizations (Aley, 2008). Dye tracing has been implemented in every hydrologic environment on the planet including wetlands, oceans, estuaries, rivers, streams, groundwater, geothermal groundwater and glacial settings.

Human

Human health and safety are addressed in partial from the MSDS sheets provided in the appendices. The dye is EPA certified to conform to the ANSI/NSF Standard 60 for use in potable public water supplies as set forth by the Clean Water Act (see a copy of the certification in the appendices) and maximum concentrations in surface water at 100 ppb. EPA (1995) states clearly that Rhodamine WT should not exceed 1,000 – 2,000 ppb at the point of groundwater discharge and it would not present an acute toxic threat at or substantially above the recommended 2,000 ppb concentration. Smart (1984) states "Persistent dye concentrations in tracer studies should not cause problems provided they are below 100 ppb". After the test, the pump will be turned on and the system flushed until the water is colorless. The water will be tested for residual dye and continued flushing until levels drop below the NSF recommended concentrations previously noted. The resurgent concentrations from the springs and in the river will not be a risk to humans since there is no consumption of this water by humans.

Snails

Endangered and non-endangered snails were considered by seeking professional recommendations and information. Tom Aley has performed numerous dye tracer tests at locations where endangered snails are present with the approval of the U.S. Fish and Wildlife Service (Aley, 2008). A literature search was performed and numerous snail experts contacted about the potential risk and the topic was also posted on internet discussion forums. The response was a unanimous general response that there is no concern or significant threat. The USGS (1973) conducted a study which exposed oyster eggs and larvae to Rhodamine WT with no abnormal growth observed. The MSDS documents "no developmental abnormalities or toxicity to oyster larvae at 100,000 ppb" which is an extremely high concentration. Dr. John Stark, who is the director and a professor at Washington State University, stated in regards to snails that Fluorescein should not pose a problem to snails if the concentration is below 300.0 ppm which is an extremely high concentration. Rhodamine WT is in the same family of dyes with similar characteristics. John Stark is an ecotoxicologist who specializes in ecological risk assessment of threatened and endangered species (see Daphnia section below).

Fish

Two potential issues, native or indigenous populations and commercial production are addressed in regards to fish. The MSDS documents that the LC50 for Rainbow Trout at 96 hours of 320,000 ppb again, an extremely high concentration. Dye tracing has been approved by federal regulatory agencies (EPA, 1995) and performed in streams and rivers for over half a century at locations that include sensitive environments and endangered species such as in Salmon spawning beds with no problems or issues (Aley, 2008). **A USGS study in 1973 exposed trout and salmon smolts to Rhodamine WT at a concentration of 10,000 ppb for 17.5 hours then increased the concentration to 375,000 ppb for an additional 3.5 hours with no ill effects to the trout or salmon. The fish remained healthy in dye free water a month after the test was completed.** Resurgent dye concentrations are expected to be very low ranging from 0.1-100 ppb from the springs and diluted after mixing with additional river water near the spring area. Even more dilution will occur downstream from more spring discharge into the river where it is anticipated concentrations of dye will be at or below the minimum detection limits. The endemic species of Shoshone Sculpin are present in the lower Malad River below the Highway 30 Bridge (Bowler, 1992 and personal communication with Malad Gorge staff, 2008). The dye is expected to be below detection limits by the time it flows through this section from the effects of dilution, biological degradation, sun light degradation, and absorption onto concrete, rock substrate and clay particles from irrigation return flows. A test on trout exposed to 2 slugs of Rhodamine WT with a maximum concentration of 13 ppb and 6 ppb for each slug, as well as several continuous injections of RWT at approximately 0.02 ppb was performed at Rueger Springs Idaho Fish and Game Aquaculture facility with no detection of dye present in gill tissue or flesh.

Daphnia

Daphnia are small, planktonic crustaceans, between .2 and 5 mm in length (Figure 5). *Daphnia* are members of the order Cladocera, and are one of the several small aquatic crustaceans commonly called water fleas because of their saltatory swimming style (although fleas are insects and thus only very distantly related). They live in various aquatic environments ranging from acidic swamps to freshwater lakes, ponds, streams and rivers (Wikipedia, 2008).

Figure 5. Photo of Daphnia crustacean (Wikipedia, 2008).

The MSDS documents the LC50 for Daphnia Magna at 170,000 ppb (again, extremely high concentration). Dr. John Stark was contacted by IDWR staff (personal communication) and discussed the risk of Fluorescein dye to both snails and Daphnia. Although this test will use Rhodamine WT, it is still in the same family of dyes with similar low risk factors and therefore useful to compare. Dr. Stark is an ecotoxicologist who specializes in ecological risk assessment of threatened and endangered species. He manages the WSU Salmon Toxicology Research

Laboratory and has recently started work on the effects of pesticides on endangered butterfly species. Dr. Stark is also a population modeler and has developed population-level risk assessments based on matrix models and differential equation models.

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Dr. Stark provided a professional paper (Walthall and Stark, 1999) to IDWR that addresses the risk of dyes to Daphnia and the research paper concluded there is little or no issues with Fluorescein dye concentrations below 337 (278±403) mg/liter (ppm). The resurgent dye concentration is expected to be several orders of magnitude less in concentration within the range of 0.1-100 ppb.

Appendix of Information Used for Proposed Implementation

1. List of References
2. Material Safety Data Sheet for Rhodamine WT
3. Flourometric Facts Bulletin – Rhodamine WT
4. Technical Data Bulletins
5. USGS Report (title page only) "Fluorometric Procedures for Dye Tracing"
6. Groundwater Tracing Handbook by Thomas Aley
7. USGS Rhodamine WT Reader Information Sources
8. Conklin Well Drilling Report

Reference and Sources of Information

1. Aley, T., 2002, Groundwater tracing handbook, Ozark Underground Labs, 44 p.

The Ozark Underground Laboratory

The Ozark Underground Laboratory, Inc. (OUL), is a private consulting and contract studies firm which provides groundwater tracing and other hydrogeological services throughout North America. The OUL has been in continuous full-time operation since 1973 under the direction of Tom Aley, who serves as Principal Hydrogeologist for the firm. The OUL typically has a full-time staff of nine people. We are not affiliated with any academic institution, and we have no academic responsibilities which could interfere with full client service. The OUL has designed and either conducted, or assisted with, over 3,500 groundwater traces in the United States and Canada. Our clients include many environmental and engineering consulting firms; other corporate and private entities; and federal, state, and local agencies.

One common misconception is that dyes may be harmful or that they will cause some sort of public relations problem. There is extensive technical literature (such as Field et al., 1995) demonstrating that the dyes present no health or environmental problems at concentrations five orders of magnitude or more above the method detection limits of modern analytical protocols. Dye tracing does not require large quantities of dyes; the dyes discussed in this handbook are safe groundwater tracing agents.

Ozark Underground Laboratory's Groundwater Tracing Handbook 2002

- Through thousands of feet of landslide debris in Alaska.
- For several miles through lava flows in Washington.
- For hundreds of feet through fractured granite aquifers in New Hampshire and Minnesota.
- Through glacial outwash, various alluvial deposits, and deep residuum to water supply and monitoring wells.
- From highway, rail, and pipe line spill sites to streams, springs, and wells.
- From perimeter points around Solid Waste Management Units (SWMUs) at RCRA and CERCLA sites to monitoring wells and other monitored points.
- From on-site sewage systems to bulkhead drains adjacent to marine shellfish beds, Washington. Based upon 1,600 dye introductions, about 23% of the sewage systems were functioning inadequately and yielded dye to sampling stations.
- Through various deposits to verify or refine time of travel calculations for groundwater remediation.
- From leaking sewers to water supply and monitoring wells, springs, streams, and building sumps.
- From leaking impoundments to springs and wells.
- From perennial stream segments to private and public water supply wells.
- For delineating wellhead protection zones.
- For assessing groundwater scenarios where the "worst case" is flow along preferential flow routes.

2. Aley, T. 2003, Procedures and criteria analysis of Fluorescein, eosine, Rhodamine wt, sulforhodamine b, and pyranine dyes in water and charcoal samplers, Ozark Underground Labs, 21 p.

3. Axelsson, G., Bjornsson, G., and Montalvo, F., 2005, Quantitative interpretation of tracer test data, Proceedings World Geothermal Congress, 24-29p.

4. Bowler, P.A., Watson, C.M., Yearsley, J.R., Cirone, P.A., 1992, Assessment of ecosystem quality and its impact on resource allocation in the middle Snake River sub- basin; (CMW, JRY, PAC - U.S. Environmental Protection Agency, Region 10; PAB - Department of Ecology and Evolutionary Biology, University of California, Irvine), Desert Fishes Council (http://www.desertfishes.org/proceed/1992/24abs55.html)

5. Field, M.S., Wilhelm R.G., Quinlan J.F. and Aley T.J., 1995, An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing, Environmental Monitoring and Assessment, vol. 38, 75-96 p.

acute toxicity of Rhodamine WT in rats to the known acute oral toxic dose in humans for several known acutely toxic chemicals. This comparison showed that none of the fluorescent dyes evaluated would present an acutely toxic threat at or substantially above the recommended 2 mg l^{-1} concentration.

ed for tracer tests. The lower, traditional maximum concentrations of 10 $\mu g\ l^{-1}$ (Wilson *et al.*, 1986, p. 8; Mull *et al.*, 1988, pp. 28 and 37) have been selected primarily for aesthetic and public relations reasons, not as a result of comprehensive toxicological testing or evaluation of the dyes. A simple calculated potential dose

6. Gaikowski, M.P., Larson, W.J., Steuer, J.J., Gingerich, W.H., 2003, Validation of two dilution models to predict chloramine-T concentrations in aquaculture facility effluent, Aquacultural Engineering 30, 2004, 127-140.

The study was conducted at the aquaculture facility at the US Geological Survey's Upper Midwest Environmental Sciences Center (UMESC). The UMESC aquaculture facility continuously discharges water through two settling lagoons into a backwater area of the Black River (La Crosse, Wisconsin, USA). The mean daily discharge seasonally ranges from 1.5 to

R5 during the two, 100 Fμ/l, rhodamine WT treatments was 275 and 262 l/min. A peristaltic pump was used to meter a rhodamine WT stock solution directly into raceway R5's inflowing water stream at 2.5 l/min to maintain a concentration of 100 μg/l for 60 min. Concurrent with the application of the rhodamine WT stock solution, the water in the raceway was "charged" with 3.69 g rhodamine WT Liquid Dye (Rhodamine WT Liquid Dye, 21% active ingredient, CAS# 528-44-9, Keystone Aniline Corporation, Chicago, IL, USA) to immediately achieve an initial active ingredient concentration of 100 μg/l. After charging the raceway, the raceway water was mixed by agitation for 5 min with raceway agitators

7. Galloway, J.M., 2004, Hydrogeologic characteristics of four public drinking water supply springs in northern Arkansas, U.S. Geological Survey Water-Resources Investigations Report 03-4307, 68 p.

8. Harvey, K.C., 2005, Beartrack mine mixing zone dye tracer study outfall 001, Napias creek Lemhi county, Idaho, Private Consulting Report by KC Harvey, LLC., 59 p.

9. Kilpatrick, F.A. and Cobb, E.D., 1985, Measurement of discharge using tracers, U.S. Geological Survey Techniques of Water-Resources Investigations Report, book 3, chapter A16.

10. Marking, L., Leif, 1969, Toxicity of Rhodamine b and Fluorescein sodium to fish and their compatibility with antimycin A, The Progressive Fish Culturist, vol. 31, July 1969, no. 3. 139-142p.

Both dyes are relatively nontoxic to fish. This is especially so in shorter exposures. A field concentration of 0.1 p.p.m. of either dye would have to be increased more than 1,000 times to be toxic to rainbow trout, a more sensitive

11. Noga, E.J., and Udomkusonsri, P., 2002, Fluorescein: a rapid, sensitive, non-lethal method for detecting skin ulceration in fish, Vet Pathol 39:726–731p.

12. Olsen, L.D. and Tenbus F.J., 2005, Design and analysis of a natural-gradient groundwater tracer test in a freshwater tidal wetland, west branch canal creek, Aberdeen proving ground, Maryland, U.S. Geological Survey Scientific Investigation Report 2004-5190, 116 p.

ent. Fluorescein dye was injected on July 17, 1998, as 0.025 liter of solution containing 50,000 milligrams per liter of sodium fluorescein, to test the hydrologic integrity of the

13. Parker, G.G., 1973, Tests of Rhodamine WT dye for toxicity to oysters and fish, Journal of Research U.S. Geological Survey, Vol. 1, No. 4, July-Aug., p. 499.

Wash. Tests showed that 48-hour exposures at 24°C of 11,000 oyster eggs per liter and 6,000 12-day-old larvae per liter, in sea water with concentrations of rhodamine WT ranging from 1 μg/l to 10 mg/l, resulted in development of the eggs to normal straight-hinge larvae and no abnormalities in the larvae development. Tests made on the smolt of both silver salmon and Donaldson trout, with the fish held for 17.5 hours in a tankfull of sea water with a dye concentration of 10 mg/l at 22°C showed no mortalities or respiratory problems. With the concentration increased to 375 mg/l, and the time extended an additional 3.2 hours, still no mortalities or abnormalities were noted. The fish remained healthy in dye-free water when last checked a month after the test.

An additional test was made on smolt (4–6 inches long) of both silver salmon and Donaldson trout. Eight salmon and eight trout were held in a tank of water from the aquaculture pond with a concentration of 10 mg/l of rhodamine WT dye. The fish were held in this tank for 17.5 hours with water at 22°C. No mortalities or respiratory problems were noted, and the fish appeared similar in behavior to those in the control tank. The dye concentration in the test tank was then increased to 375 mg/l for an additional 3.2 hours. Again, no mortalities or other problems were observed. The fish tested remained healthy in dye-free water when last checked approximately 1 month after the test.

14. Putnam, L.D. and Long A.J., 2007, Characterization of ground-water flow and water quality for the Madison and minnelusa aquifers in northern Lawarence county, South Dakota, U.S. Geological Survey Scientific Investigation Report 2007-5001, 73 p.

15. Quinlan, J.F. and Koglin, E.N. (EPA), 1989, Ground-water monitoring in karst terrranes: recommended protocols and implicit assumptions, U.S. Environmental Protection Agency, EPA 600/x-89/050, IAG No. DW 14932604-01-0, 79 p.

dyes generally used for tracing ground water are benign and harmless in the concentrations commonly employed (Smart, 1984).

Tracing agents are fundamental tools for discovery and prediction of the velocity and dispersal-path of pollutants in ground water and surface water. Interpretation of data from tracer studies makes it possible to protect water quality, public health, and aquatic life. Such data are crucial to the development of wellhead and springhead protection strategies and can be essential for the calibration of computer models of water flow and pollutant movement. Tracing is cost-efficient and is often the only way to get critically needed data.

A further analogy describing the use of tracing agents can be made. Doctors use vaccines and a wide range of diagnostic techniques to prevent and treat illnesses. Some of these vaccines and techniques have definite risks associated with their use. These risks are assumed by an informed patient because the consequences of not preventing or not diagnosing an illness far outweigh the slight risk from use of the vaccine or diagnostic technique.

If and when state officials establish regulations governing the use of dyes or any other ground-water tracer, they should require their use by knowledgeable, experienced professionals.

16. Smart, C. and Simpson B.E., 2002, Detection of fluorescent compounds in the environment using granular activated charcoal detectors, Environmental Geology, vol. 42, 538-545 p.

17. Spangler, L.E., and Susong, D.D., 2006, Use of dye tracing to determine ground-water movement to Mammoth Crystal springs, Sylvan pass area, Yellowstone national park, Wyoming, U.S. Geological Survey Scientific Investigations Report 2006-5126, 19 p.

18. Smart, P.L., 1984, A review of the toxicity of twelve fluorescent dyes used for water tracing, National Speleological Society publication, vol. 46, no. 2: 21-33.

Based on the experimental results reviewed above, there is no evidence of either a short or long term toxic hazard to dye users or those drinking water containing tracer dyes.

above that enduring tracer concentrations as high as 1 mg/1 would not be detrimental to aquatic ecosystems.

In conclusion, there is no evidence of significant bioaccumulation for any of the tracer dyes in fish. The most sensitive aquatic organisms to the dyes are the developmental stages of shellfish, and algae. These, therefore, determine the maximum prolonged dye concentration which can be recommended. This limit is set at 1 mg/1, well above the persistent dye concentrations commonly used in tracer tests, and at least one order of magnitude above the visible threshold. There is no evidence that short-term exposure to concentrations in excess of 1 mg/1, such as could occur transiently at injection sites, are harmful, but prior dilution should be employed if rapid dispersion and dilution of the tracer dye is not expected.

dle et al. (1983). Therefore, photo-decomposition product toxicity appears only to be a problem for Eosine.

The acute and chronic toxicity of all the tracer dyes in mammal systems is sufficiently low that no danger should result in their use, providing normal precautions are observed during dye handling. However, only three tracers can be demonstrated to cause minimal carcinogenic and mutagenic hazard, Tinopal CBS-X, Flourescein and Rhodamine WT. Conversely, Rhodamine B is known to be carcinogenic

19. Taylor, C.J., and Greene E.A., Hydrogeologic characterization and methods used in the investigation of karst hydrology, U.S. Geological Survey field techniques for estimating water fluxes between surface water and ground water, chapter 3, Techniques and Methods 4-D2, 71-114 p.

20. Turner Designs, Inc., A practical guide to flow measurement, www.turnerdesigns.com.

21. U.S. Bureau of Reclamation Water Measurement Manual, 2001, http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/

22. Walthall, W.K., and Stark J.D., 1999, The acute and chronic toxicity of two xanthene dyes, Fluorescein sodium salt and phloxine B, to Daphnia pulex, Environmental Pollution volume 104, pages 207-215.

threat to natural populations. The concentration of fluorescein necessary to elicit even a sublethal response was quite high and beyond those likely to be encountered following application to agroecosystems or in urban settings. While *D. pulex* neonates do appear to be

23. Wilson, J.F., Cobb, E.D., and Kilpatrick F.A., 1986, Fluorometric procedures for dye tracing, U.S. Geological Survey Techniques of Water-Resources Investigations of the United States Geological Survey, Applications of Hydraulics, book 3, chapter A12, 43 p.

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Volume 46 Number 2: 21-33 - October 1984
A publication of the National Speleological Society

A Review of the Toxicity of Twelve Fluorescent Dyes Used for Water Tracing
P.L. Smart

Abstract

Toxicological information is reviewed for twelve fluorescent dyes used in water tracing, Fluorescent Brightener 28, Tinopal CBS-X, Amino G Acid, Diphenyl Brilliant Flavine 7GFF, Pyranine, Lissamine Yellow FF, Fluorescein, Eosine, Rhodamine WT, Rhodamine B, Sulphorhodamine B and Sulphorhodamine G. Mammalian tests indicate a low level of both acute and chronic toxicity. **However, only three tracers could be demonstrated not to provide a carcinogenic or mutagenic hazard**. These were Tinopal CBS-X, **Fluorescein** and **Rhodamine WT**. Rhodamine B is a known carcinogen and should not be used. In aquatic ecosystems, larval stages of shellfish and algae were the most sensitive. Persistent dye concentrations in tracer studies should not cause problems provided they are below 100 µg/l.

http://www.caves.org/pub/journal/PDF/V46/v46n2-Smart.htm

BRIGHT DYES™ MATERIAL SAFETY DATA SHEET
FWT RED™ 200 LIQUID
PAGE 1 OF 3

MSDS PREPARATION INFORMATION

PREPARED BY:	T. P. MULDOON (937) 886-9100
DATE PREPARED:	1/1/08

PRODUCT INFORMATION

MAUNFACTURED BY:	KINGSCOTE CHEMICALS 3334 S. TECH BLVD. MIAMISBURG, OHIO 45342
CHEMICAL NAME	NOT APPLICABLE
CHEMICAL FORMULA	NOT APPLICABLE
CHEMICAL FAMILY	XANTHENE DYE FORM

HAZARDOUS INGREDIENTS

DESCRIPTION	%	T.L.V.	C.A.S. #
TRIMELLITIC ACID	3.0	NONE	528-44-9

	LD/50, SPECIES	LC/50, SPECIES
ORAL (MOUSE)	2500 MG/KG	NONE AVAILABLE
DERMAL (RABBIT)	NOT AVAILABLE	NOT AVAILABLE

PHYSICAL DATA

PHYSICAL STATE	LIQUID
ODOR AND APPEARANCE	DARK RED LIQUID WITH MILD ODOR
SPECIFIC GRAVITY	~1.15
VAPOR DENSITY (mm Hg @ 25 ° C)	NOT APPLICABLE
VAPOR DENSITY (AIR =1)	NOT APPLICABLE
EVAPORATION RATE (Butyl Acetate = 1)	NOT APPLICABLE
BOILING POINT	~ 100 degrees. C (212 degrees. F)
FREEZING POINT	~ 10 degrees C (14 degrees F)
pH	10.4 TO 10.8
SOLUBILITY IN WATER	VERY SOLUBLE

FIRE HAZARD

CONDITION OF FLAMMABILITY	NON-FLAMABLE
MEANS OF EXTINCTION	WATER FOG, CARBON DIOXIDE, DRY CHEMICAL, WEAR SCBA
FLASH POINT AND METHOD	NOT APPLICABLE
UPPER FLAMABLE LIMIT	NOT APPLICABLE
LOWER FLAMABLE LIMIT	NOT APPLICABLE
AUTO-IGNITION TEMPERATURE	NOT APPLICABLE
HAZARDOUS COMBUSTION PRODUCTS	BURNING MAY PRODUCE OXIDES OF CARBON & NITROGEN
UNUSUAL FIRE HAZARD	NOT APPLICABLE

EXPLOSION HAZARD

SENSITIVITY TO STATIC DISCHARGE	NOT APPLICABLE
SENSITIVITY TO MECHANICAL IMPACT	NOT APPLICABLE

REACTIVITY DATA

PRODUCT STABILITY	STABLE
PRODUCT INCOMPATIBILITY	DO NOT MIX WITH ACIDS
CONDITIONS OF REACTIVITY	NOT APPLICABLE
HAZARDOUS DECOMPOSITION PRODUCTS	SEE HAZARDOUS COMBUSTION PRODUCTS

TOXICOLOGICAL PROPERTIES

SYMPTOMS OF OVER EXPOSURE FOR EACH POTENTIAL ROUTE OF ENTRY:

INHALLATION, ACUTE	TRIMELLITIC ACID MAY CAUSE IRRITATION
INHALATION, CHRONIC	NOT KNOWN
SKIN CONTACT	MAY BE IRRITATING TO THE SKIN. WILL CAUSE TEMPORARY STAINING OF THE SKIN ON CONTACT.
EYE CONTACT	MAY CAUSE IRRITATION
INGESTION	URINE MAY BE A RED COLOR UNTIL THE DYE HAS BEEN WASHED THROUGH THE SYSTEM.
EFFECTS OF ACUTE EXPOSURE	DIRECT CONTACT MAY CAUSE IRRITATION TO THE EYES, SKIN, AND RESPIRATORY TRACT.
EFFECTS OF CHRONIC EXPOSURE	NOT KNOWN
THRESHOLD OF LIMIT VALUE	NOT APPLICABLE
CARCINOGENICITY	NOT LISTED AS A KINOWN OR SUSPECTED CARCINOGEN BY IARC, NTP OR OSHA.
TERATOGENICITY	NONE KNOWN
MUTAGENICITY	CONFLICTING EVIDENCE AS TO MUTAGENICITY OF THE DYE CONTAINED IN THIS PRODUCT.
TOXICOLOGY SYNERGISTIC PRODUCTS	NONE KNOWN

REGULATORY INFORMATION

SARA SECTION 303:	NONE FOUND
SARA (311, 312) HAZARD CLASS:	IMMEDIATE HEALTH HAZARD
SARA (313) REPORTABLE CHEMICAL (%):	NONE
METAL CONTENT:	THIS PRODUCT IS NOT A METALLIZED DYE
TSCS INVENTORY STATUS	ALL COMPONENTS ARE INCLUDED ON TSCA SECTION 8
CALIFORNIA PROPOSITION 65 CHEMICALS:	NONE
TSCA SECTION 12 (B) EXPORT REGULATIONS:	NOT SUBJECT TO TSCA 12 (b) EXPORT REGULATION

ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION:	LC50: >320 mg/L RAINBOW TROUT (96 Hour) LC50: 170 mg/L DAPHINA MAGNA

NO DEVELOPMENTAL ABNORMALITIES OR TOXICITY TO OYSTER LARVAE AT 100 mg/L

PREVENTATIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT

GLOVES	RUBBER
RESPIRATORY	NONE REQUIRED UNDER NORMAL CONDITIONS
EYE PROTECTION	GOGGLES
CLOTHING	PROTECTIVE CLOTHING SHOULD BE WORN WHERE CONTACT IS UNAVOIDABLE.
OTHER	HAVE ACCESS TO EMERGENCY EYEWASH.
ENGINEERING CONTROLS	NOT NECESSARY UNDER NORMAL CONDITIONS USE LOCAL VENTILATION IF DUSTY CONDITIONS EXIST.
SPILL OR LEAK RESPONSE	CONTAIN AND CLEAN UP SPILL IMMEDIATELY, PREVENT FROM ENTERING FLOOR DRAINS. SWEEP POWDERS AND PLACE IN WASTE DISPOSAL CONTAINER, FLUSH AFFECTED AREA WITH WATER.
WASTE DISPOSAL	INCINERATE OR REMOVE TO A SUITABLE SOLID WASTE DISPOSAL SITE, DISPOSE OF ALL WASTES IN ACCORDANCE WITH FEDERAL, STATE AND LOCAL REGULATIONS.
HANDELING PROCEDURES AND EQUIPMENT	NO SPECIAL REQUIREMENTS.
STORAGE REQUIREMENTS	STORE AT ROOM TEMPERATURE BUT ABOVE THE FREEZING POINT OF WATER
SHIPPING INFORMATION	KEEP FROM FREEZING

FIRST AID MEASURES

FIRST AID EMERGENGY PROCEDURES

EYE CONTACT	FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION IF IRRITATION PERSISTS.
SKIN CONTACT	WASH SKIN THOROUGHLY WITH SOAP AND WATER. GET MEDICAL ATTENTION IF IRRITATION DEVELOPS.
INHALATION	IF DUST IS INHALED, MOVE TO FRESH AIR. IF BREATHING IS DIFFICULT GIVE OXYGEN AND GET IMMEDIATE MEDICAL ATTENTION.
INGESTION	DRINK PLENTY OF WATER AND INDUCE VOMITING. GET MEDICAL ATTENTION IF LARGE QUANTITIES WERE INGESTED OR IF NAUSEA OCCURS. NEVER GIVE FLUIDS OR INDUCE VOMITING IF THE PERSON IS UNCONSCIOUS OR HAS CONVULSIONS.

SPECIAL NOTICE

ALL INFORMATION, RECOMMENDATIONS AND SUGGESTIONS APPEARING HEREIN CONCERNING THIS PRODUCT ARE BASED UPON DATA OBTAINED FROM MANUFACTURER AND/OR RECOGNIZED TECHNICAL SOURCES; HOWEVER, KINGSCOTE CHEMICALS MAKES NO WARRANTY, REPRESENTATION OR GUARANTEE AS TO THE ACCURACY, SUFFICIENCY OR COMPLETENESS OF THE MATERIAL SET FORTH HEREIN. IT IS THE USER'S RESPONSIBILITY TO DETERMINE THE SAFETY, TOXICITY AND SUITABILITY OF HIS OWN USE, HANDLING, AND DISPOSAL OF THE PRODUCT. ADDITIONAL PRODUCT LITERATURE MAY BE AVAILABLE UPON REQUEST. SINCE ACTUAL USE BY OTHERS IS BEYOND OUR CONTROL, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE BY KINGSCOTE CHEMICALS AS TO THE EFFECTS OF SUCH USE, THE RESULTS TO BE OBTAINED OR THE SAFETY AND TOXICITY OF THE PRODUCT, NOR DOES KINGSCOTE CHEMICALS ASSUME ANY LIABILITY ARISING OUT OF USE BY OTHERS OF THE PRODUCT REFERRED TO HEREIN. THE DATA IN THE MSDS RELATES ONLY TO SPECIFIC MATERIAL DESIGNATED HEREIN AND DOES NOT RELATE TO USE IN COMBINATION WITH ANY OTHER MATERIAL OR IN ANY PROCESS.

END OF MATERIAL SAFETY DATA SHEET

Division of Kingscote Chemicals

WATER TRACING DYE
FWT RED PRODUCTS

TECHNICAL DATA BULLETIN

Bright Dyes FWT Red products are specially formulated versions of Rhodamine WT dye for convenient use in water tracing and leak detection studies. This bright, fluorescent red dye is certified by NSF International to ANSI/NSF Standard 60 for use in drinking water. It may be detected visually, by ultraviolet light and by appropriate fluorometric equipment. Today it is most often used visually. Visually the dye appears bright pink to red, depending on its concentration and under ultraviolet light as bright orange.

The dye is resistant to absorption on most suspended mater in fresh and salt water. Compared to Bright Dyes FLT Yellow/Green products it is significantly more resistant to degradation by sunlight and when used in fluorometry, stands out much more clearly against background fluorescence. As always the use and suitability of these products for any specific application should be evaluated by a qualified hydrologist or other industry professional.

General Properties	Tablets	FWT Red 25 Liquid	Powders
Detectability of active ingredient [1]	Visual <100 ppb	Visual <100 ppb	Visual <100 ppb
Maximum absorbance wavelength [2]	550/588 nm	550/588 nm	550/588 nm
Appearance	Dark red convex 1.6cm diameter	Clear dark red aqueous solution	Dark red fine powder
NSF (Max use level in potable water)	0.3 ppb	0.8 ppb	0.1 ppb
Weight	1.05 gms ± 0.05		
Dissolution Time [3]	50% < 3 minutes 95% < 6 minutes		50% < 3 minutes 95% < 6 minutes
Specific Gravity		1.03 ± 0.05 @ 25° C	
Viscosity [4]		1.3 cps	
pH		8.7 ± 0.5 @ 25° C	

Coverage of Products	One Tablet	One Pint Liquid	One Pound Powder
Light Visual	604 gallons	31,250 gallons	604,000 gallons
Strong Visual	60 gallons	3,125 gallons	60,400 gallons

Caution: These products may cause irritation and/or staining if allowed to come in contact wit the skin. The use of gloves and goggles is recommended when handling this product, as with any other dye or chemical.

To our best knowledge the information and recommendations contained herein are accurate and reliable. However, this information and our recommendations are furnished without warranty, representation, inducement, or license of any kind, including, but not limited to the implied warranties and fitness for a particular use or purpose. Customers are encouraged to conduct their own tests and to read the material safety data sheet carefully before using.

[1] In deionized water in 100 ml flask. Actual detectability and coverage in the field will vary with specific water conditions.
[2] No significant change in fluorescence between 6 and 11 pH.
[3] (One tablet, 1 gram of powder), in flowing deionized water in a 10 gallon tank.
[4] Measured on a Brookfield viscometer, Model LV, UL adapter, 60 rpm @ 25° C.

Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter A12

FLUOROMETRIC PROCEDURES FOR DYE TRACING

By James F. Wilson, Jr., Ernest D. Cobb,
and Frederick A. Kilpatrick

BOOK 3

APPLICATIONS OF HYDRAULICS

Revised 1986

Click here to return to USGS Publications

CONTENTS

	Page
Preface	III
Abstract	1
Introduction	1
General description of fluorescence	2
Fluorescent dyes	3
Types recommended for tracing	3
Properties of dyes	5
Factors that affect fluorescence	5
Sorption	7
Biological effects	7
Spectral characteristics	8
Fluorometers	8
General description	8
Selection of optical components	11
Lamps	11
Filters	12
Sample holders	14
Photomultiplier	15
Range control	15
Preferred systems	15
Accessory equipment	15
Temperature-control apparatus	15
Portable power supplies	16
Fluorometers—Continued	
Accessory equipment—Continued	
Continuous-sampling equipment	17
Fluorometer operation	18
General procedure in the laboratory	18
Preparations	18
Background readings	19
Sample testing	19
Special procedures in the field	20
Discrete sampling	20
Flow-through sampling	21
Troubleshooting	22
Fluorometer calibration	22
Concentration units	23
Preparation of standard solutions	23
Equipment and supplies	23
Serial dilution procedure	24
Testing procedure	28
Calibration curves	28
Calibration of the flow-through cuvette	31
Determination of sample concentration	31
Aerial photography as a supplement to fluorometry	31
Selected references	32

The Ozark Underground Laboratory's

GROUNDWATER TRACING HANDBOOK

A handbook prepared for the use of clients and colleagues of the Ozark Underground Laboratory
2002

Thomas Aley

TABLE OF CONTENTS

Introduction **Page v**
The Ozark Underground Laboratory v
Purpose of this Handbook v
Tracer Dyes: An Under-Utilized Groundwater Tool v
Five Critical Factors for Successful Groundwater Tracing vii
Selection of Appropriate Dyes and Dye Quantitites **Page 1**
Introduction 1
The Most Useful Dyes for Problem Solving 1
Tracing Nomenclature and Dye Concentrations in "As Sold" Mixtures 1
Performance Factors: Relative Fluorescence Intensities 3
Performance Factors: Resistance to Adsorption and Other Losses 5
Performance Factors: Fluorescence Interference 7
Performance Factors: Losses in Surface Water 10
Performance Factors: Limitations in Acidic and Mine Waters 11
Selecting Dye Quantities 13
Introducing Tracer Dyes **Page 15**
Sites for Dye Introduction 15
Selecting Water Quantities 16
Use of "Dry Sets" 17
Mixing Dyes 17
Sampling for Tracer Dyes **Page 19**
Activated Carbon Samplers 19
Sampler Placement 20
How Quantitative Are the Samplers? 21
How Often Should Samplers Be Changed? 22
When Do Samplers Miss Dyes? 22
Maintaining the Integrity of Samplers 23
Water Samples 24
Dye Analysis **Page 25**
Sampler Washing 25
Sampler Elution 26
Water Samples 27
Analytical Instruments 27
Instrumental Analysis of Samples 28
OUL Software and Data Output 30
Designing Effective Groundwater Tracing Studies **Page 33**
References **Page 35**

Rhodamine WT Reader

Readings on the Reactivity and Transport Characteristics of This Tracer

REGULATORY STANDARDS

- The standards established by the Environmental Protection Agency in the Federal Register (Vol. 63, No. 40) state the maximum Rhodamine WT concentrations to be 10 micrograms per liter for water entering a drinking water plant (prior to treatment and distribution) and 0.1 micrograms per liter in drinking water.

The US Geological Survey provides the regulatory standard references for information purposes ONLY. This information was obtained in August of 2004.

BACKGROUND FOR ANY APPLICATION

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Detection of diethylnitrosamine in nitrate-rich water following treatment with rhodamine flow tracers. SL Abidi, *Water Research*, **16**: 199, 1982.

COMMERCIAL PRODUCT INFORMATION

The US Geological Survey does *NOT* endorse or recommend commercial products.

The following is provided *ONLY* for identification and information purposes.

Rhodamine WT

Sensient Corporation

http://www.sensient-tech.com/solutions/industrial_colors.htm

800- 558-9892

Keystone Corporation

http://www.dyes.com/

800-522-4dye

Fluorometers

Seapoint Sensors, Inc

http://www.seapoint.com/srf.htm

603-642-4921

Turner Designs

http://turnerdesigns.com

877-316-8049

Opti-Sciences

http://www.optisci.com/ps.htm

603-883-4400
YSI Inc.
Model 6130 Rhodamine WT Sensor
http://216.68.81.171/852568CB0010F86A/web+by+document+type/CF82E634926142FB85256AF8005E9FCF?Open
800-897-4151

International Chemical Safety Cards
http://www.itcilo.it/english/actrav/telearn/osh/ic/37299898.htm
http://www.inchem.org/documents/icsc/icsc/eics0325.htm

Compilation by Ken Bencala and Marisa Cox, September 23, 2005
http://water.usgs.gov/nrp/proj.bib/bencala.html
kbencala@usgs.gov

Phil S

Form 238-7
6/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Well ID No.
Inspected by
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D 0043236
DRILLING PERMIT NO.
Water Right or Injection Well No.

2. OWNER:
Name Ronald Conklin
Address PO Box 67
City Bliss State ID Zip 83314

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 6 North ☐ or South ☒
Rge. 14 East ☒ or West ☐
Sec. 31, ____ 1/4 NE 1/4 NW 1/4
Gov't Lot ____ County Gooding
Lat: 42 : 32.839 Long: 114 : 59.754
Address of Well Site 1230 Old Malad River Hwy
(Give at least name of road + Distance to Road or Landmark) City Bliss
Lt. ____ Blk. ____ Sub. Name ____

4. USE:
☒ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement etc.)
☒ New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD:
☒ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method
Bentonite	0	18	4 bags	poured

Was drive shoe used? ☐ Y ☒ N Shoe Depth(s) ____
Was drive shoe seal tested? ☐ Y ☐ N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6	+2	21	.250	Steel	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ____ Length of Tailpipe ____
Packer ☐ Y ☐ N Type ____

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method ____
Screen Type & Method of Installation ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
						☐	☐
						☐	☐
						☐	☐

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
116 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____
plate

12. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

Water Temp. ____ Bottom hole temp. ____
Water Quality test or comments: ____
Depth first Water Encounter ____

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
8	0	7	topsoil		
	7	17	grey basalt		
	17	20	brown ash		
	20	23	grey basalt		
	23	49	grey basalt		X
	49	136	fractured grey basalt	X	
	136	145	brown ash		X
	145	164	fractured grey basalt	X	
	164	170	black cinders	X	
	170	200	tan clay		X
			Actual hole sizes are 8 3/4" + 6 1/4"		

RECEIVED
OCT 04 2006
DEPT. OF WATER RESOURCES SOUTHERN REGION

Completed Depth 200' (Measurable)
Date: Started 9-13-06 Completed 9-13-06

14. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Elsing Drilling + Pump Firm No. 669
Principal Driller Craig Egan Date 9-14-06
and
Driller or Operator II ____ Date ____
Operator I Alex Putra Date 9-14-06
Principal Driller and Rig Operator Required.
Operator I must have signature of Driller/Operator II.

FORWARD WHITE COPY TO WATER RESOURCES