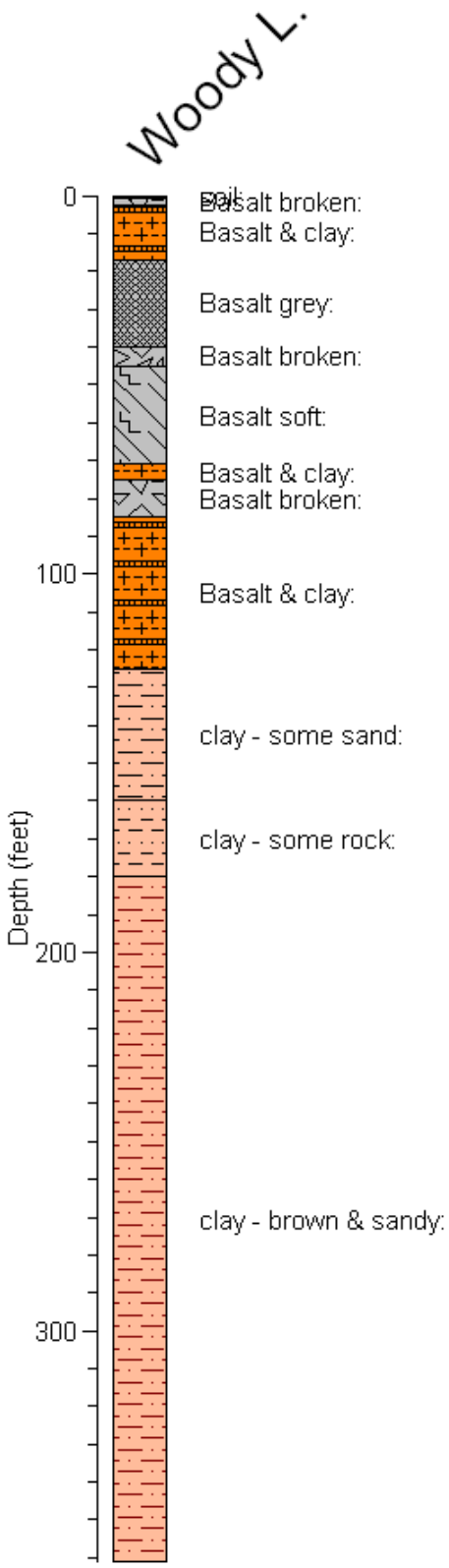
APPENDIX A – Geologic Map Descriptions

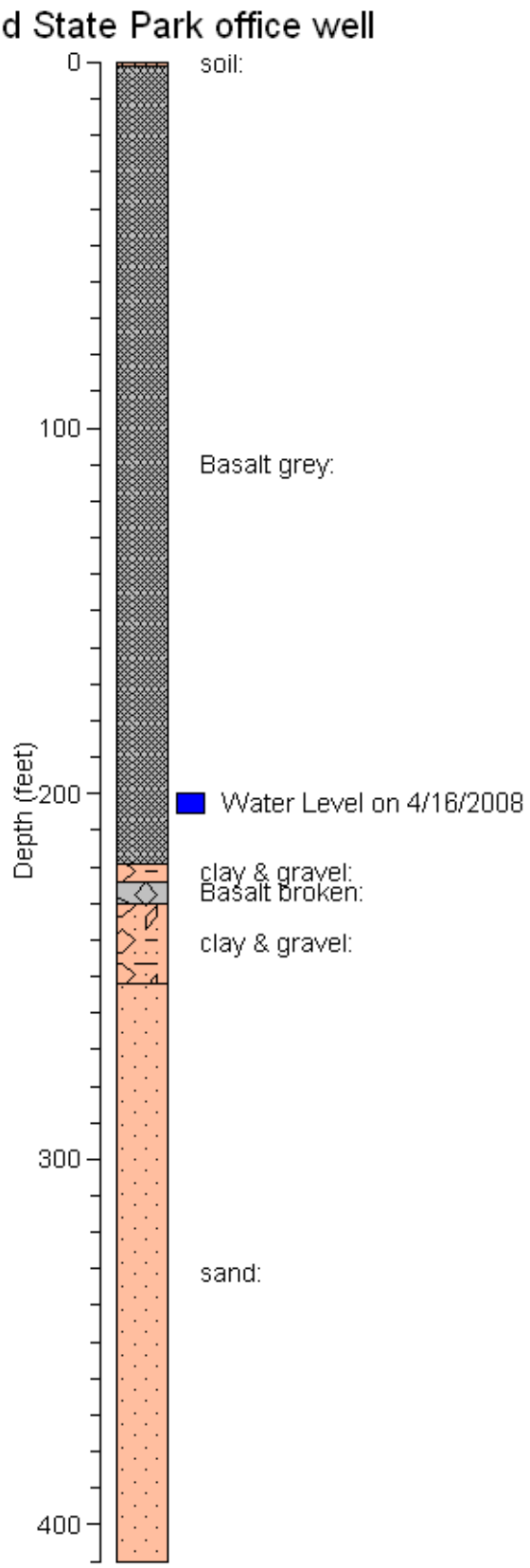
Description of geologic map units from Thousand Springs Quadrangle map by Gillerman et al, 2005 Idaho Geological Survey.

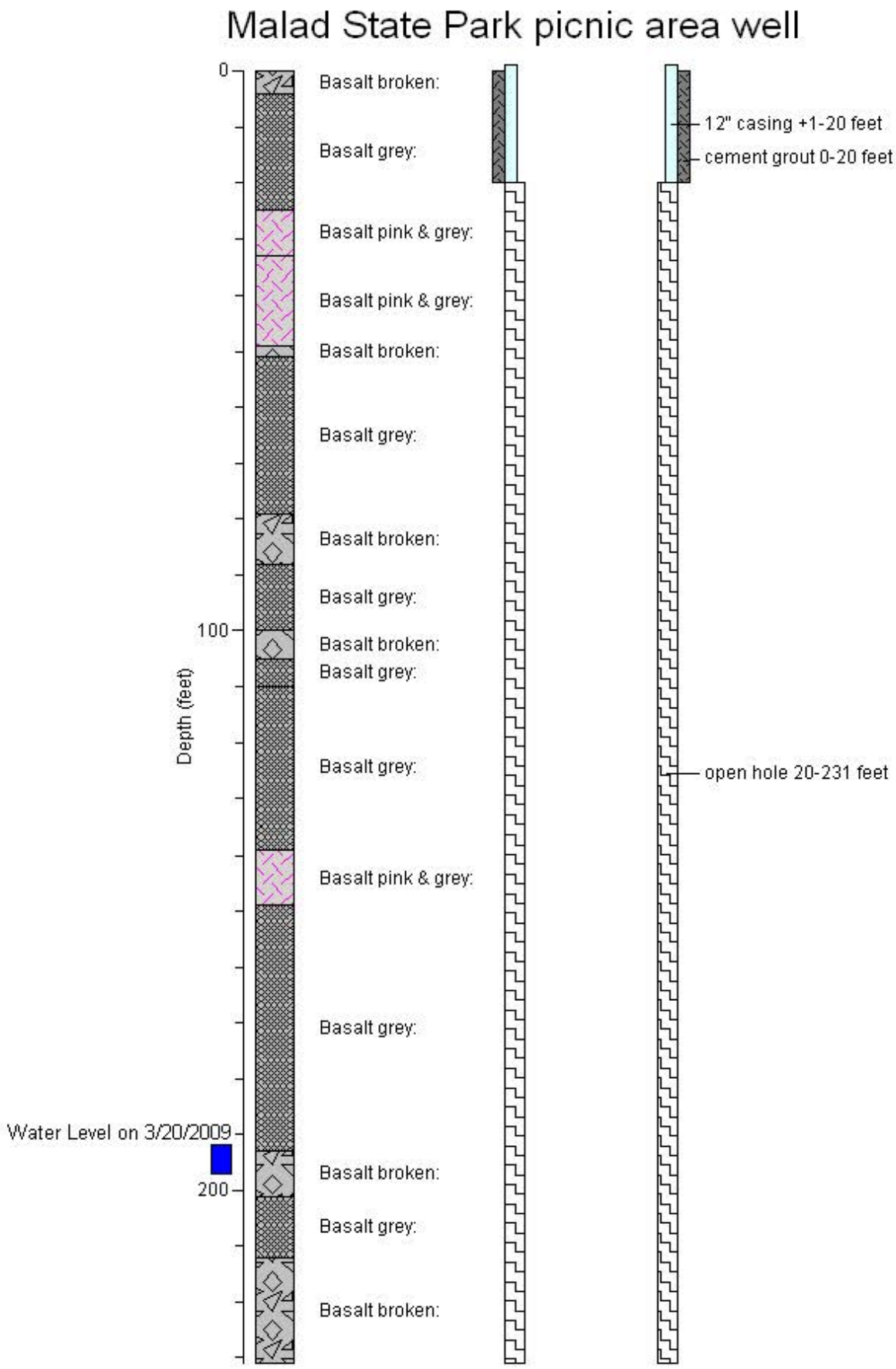
Qgb **Basalt of Gooding Butte (Pleistocene)**—Fine-grained basalt with scattered to abundant plagioclase phenocrysts up to 1 cm in length, and plagioclase-olivine intergrowths up to 1 cm in diameter. Olivine is olive-greenish-brown in color and is mostly clustered. The basalt is diktytaxitic and vesicular with vesicles ranging from small and spherical to large and irregular. Common carbonate filling and coating in voids. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Source is Gooding Butte, located 6 miles northeast of Tuttle. Surface subdued, soil covered and mostly farmed. Outcrops uncommon on upland surface but well exposed in Malad Gorge and on the east bluff of Billingsley Creek valley. Equivalent to Thousand Springs Basalt, Malad Member of Malde and others (1963). Topography contrasts with areas of basalt of Notch Butte and the basalt of Bacon Butte, younger unit. Almost no basalt pressure ridges rise above a nearly complete mantle of loess, except where scoured by Malad River floods. Surface drainage is moderately developed. Thickness of mantle ranges 3-25 feet; commonly 3-12 feet thick. Soil caliche (duripan) is typically well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche is highly variable. Most of the land is cultivatable.

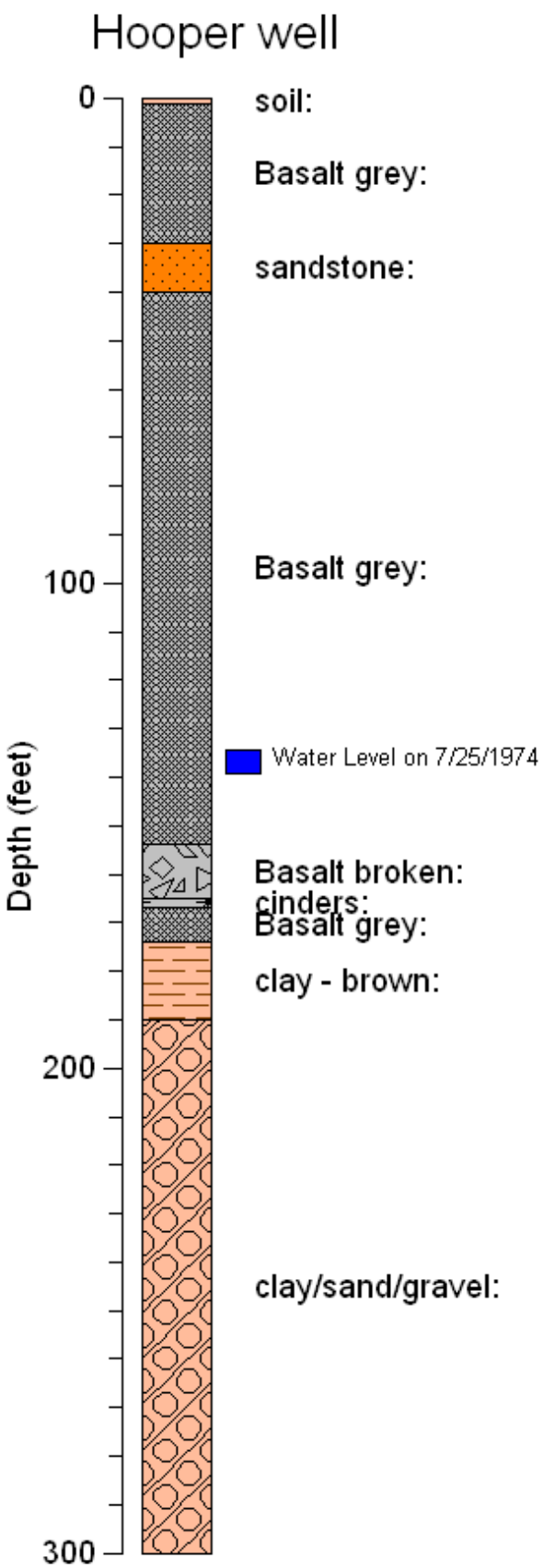
Qma **Madson Basalt (Pleistocene)**—Fine- to medium-grained, dark gray basalt with very abundant olivine grains and clots up to 4 mm in diameter. Exposed only in Malad Gorge below basalt of Gooding Butte. Equivalent to the Madson Basalt of Malde and Powers (1972). Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Tauxe and others (2004) report an $^{40}Ar/^{39}Ar$ weighted mean plateau age of 0.404 Ma for this unit (their sample sr12, Madson Basalt). Source undetermined, but Malde (1971) suggests the source was likely to the east. Small area above Billingsley Creek near Johnson Grade mapped as Madson by Covington and Weaver (1990) is more consistent texturally with basalt of Gooding Butte than with Madson, and therefore we include it in the Gooding Butte unit.

APPENDIX B – Geologic Well Logs




Malad State Park office well
0
100
200
300
400
Depth (feet)
soil:
Basalt grey:
Water Level on 4/16/2008
clay & gravel:
Basalt broken:
clay & gravel:
sand:


Malad State Park picnic area well
0
100
200
Depth (feet)
Basalt broken:
Basalt grey:
Basalt pink & grey:
Basalt pink & grey:
Basalt broken:
Basalt grey:
Basalt broken:
Basalt grey:
Basalt broken:
Basalt grey:
Basalt grey:
Basalt pink & grey:
Basalt grey:
Water Level on 3/20/2009
Basalt broken:
Basalt grey:
Basalt broken:
12" casing +1-20 feet
cement grout 0-20 feet
open hole 20-231 feet


Hooper well
0
100
200
300
Depth (feet)
soil:
Basalt grey:
sandstone:
Basalt grey:
Water Level on 7/25/1974
Basalt broken:
cinders:
Basalt grey:
clay - brown:
clay/sand/gravel:

APPENDIX C – Fluorescein Lab Results

Ozark Underground Laboratory, Inc. for Idaho Dept. of Water Resources

Project Name: Malad Gorge G.W. Trace
Samples collected by: Neal Farmer
Date Samples Shipped: April 28, 2009
Date Samples Rec'd at OUL: April 29, 2009
Date Analyzed by OUL: May 1, 4 and 5, 2009

Table 1. Results for charcoal and water samples analyzed for the presence of fluorescein dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb). All results are for charcoal unless otherwise indicated.

OUL #	Station #	Station Name	Date/Time Placed	Date/Time Collected	Fluorescein Results	
					Peak	Conc.
S9230	IPCo.Div	Idaho Power Diversion	4/7/09 1030	4/14/09 1030	515.4	70.7
S9231	MG-1	Malad Gorge #1	4/7/09 1100	4/14/09 1120	ND	
S9232	MG-2	Malad Gorge #2	4/7/09 1110	4/14/09 1130	515.5	4.57
S9233	MG-3	Malad Gorge #3	4/7/09 1120	4/14/09 1140	ND	
S9234	MG-4	Malad Gorge #4	4/7/09 1130	4/14/09 1145	ND	
S9235	MG-5	Malad Gorge #5	4/7/09 1140	4/14/09 1155	ND	
S9236	MG-6	Malad Gorge #6	4/7/09 1150	4/14/09 1200	515.3	1.44
S9237	MG-7	Malad Gorge #7	4/7/09 1200	4/14/09 1205	515.9	1,310
S9238	MG-8	Malad Gorge #8	4/7/09 1210	4/14/09 1210	515.9	446
S9239	MG-9	Malad Gorge #9	4/7/09 1220	4/14/09 1215	515.5	35.2
S9240	Laboratory control charcoal blank					
S9241	MG-10	Malad Gorge #10	4/7/09 1230	4/14/09 1225	515.5	216
S9242	MG-11	Malad Gorge #11	4/7/09 1240	4/14/09 1230	ND	
S9312	IPCo.Div	Idaho Power Diversion	Water	4/14/09 1030	ND	
S9313	MG-2	Malad Gorge #2	Water	4/14/09 1130	ND	
S9314	MG-6	Malad Gorge #6	Water	4/14/09 1200	ND	
S9315	MG-7	Malad Gorge #7	Water	4/14/09 1205	510.6 (1)	0.012
S9316	MG-8	Malad Gorge #8	Water	4/14/09 1210	ND	
S9317	MG-9	Malad Gorge #9	Water	4/14/09 1215	ND	
S9333	MG-10	Malad Gorge #10	Water	4/14/09 1225	ND	

Footnotes: ND = No dye detected. (1) = A fluorescence peak is present that does not meet all the criteria for this dye. However, it has been calculated as a positive dye result because dye was found in the corresponding charcoal sample.

APPENDIX D– Miscellaneous Information

The NSS Bulletin - **ISSN 1090-6924**
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 DYESMATERIAL SAFETY DATA SHEET
FLT YELLOW/GREEN LIQUID CONCENTRATE
PAGE 1 OF 3

MSDS PREPARATION INFORMATION

PREPARED BY:	T. P. MULDOON (937) 886-9100
DATE PREPARED:	1/01/05

PRODUCT INFORMATION

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

HAZARDOUS INGREDIENTS

NONE PER 29 CFR 1910.1200

PHYSICAL DATA

PHYSICAL STATE	LIQUID
ODOR AND APPEARANCE	YELLOW/GREEN, WITH NO APPARENT ODOR
SPECIFIC GRAVITY	APPROXIMATELY 1.05
VAPOR DENSITY (mm Hg @ 25 ° C)	~23.75
VAPOR DENSITY (AIR =1)	~0.6
EVAPORATION RATE (Butyl Acetate = 1)	~1.8
BOILING POINT	100 degrees C (212 degrees F)
FREEZING POINT	0 degrees C (32 degrees F)
pH	8.0 OR ABOVE
SOLUBILITY IN WATER	HIGHLY SOLUBLE

FIRE HAZARD

CONDITION OF FLAMMABILITY	NON-FLAMABLE
MEANS OF EXTINCTION	WATER FOG, CARBON DIOXIDE, OR DRY CHEMICAL
FLASH POINT AND METHOD	NOT APPLICABLE
UPPER FLAMABLE LIMIT	NOT APPLICABLE
LOWER FLAMABLE LIMIT	NOT APPLICABLE
AUTO-IGNITION TEMPERATURE	NOT APPLICABLE
HAZARDOUS COMBUSTION PRODUCTS	NOT APPLICABLE
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	NONE KNOWN
CONDITIONS OF REACTIVITY	NOT APPLICABLE
HAZARDOUS DECOMPOSITION PRODUCTS	NONE KNOWN

TOXICOLOGICAL PROPERTIES

SYMPTOMS OF OVER EXPOSURE FOR EACH POTENTIAL ROUTE OF ENTRY:

INHALLATION, ACUTE	NO HARMFUL EFFECTS EXPECTED.
INHALATION, CHRONIC	NO HARMFUL EFFECTS EXPECTED.
SKIN CONTACT	WILL TEMPORARILY GIVE SKIN A YELLOW/GREEN COLOR.
EYE CONTACT	NO HARMFUL EFFECTS EXPECTED.
INGESTION	URINE MAY BE A YELLOW/GREEN COLOR UNTIL THE DYE HAS BEEN WASHED THROUGH THE SYSTEM.
EFFECTS OF ACUTE EXPOSURE	NO HARMFUL EFFECTS EXPECTED
EFFECTS OF CHRONIC EXPOSURE	NO HARMFUL EFFECTS EXPECTED
THRESHOLD OF LIMIT VALUE	NOT APPLICABLE
CARCINOGENICITY	NOT LISTED AS A KINOWN OR SUSPECTED CARCINOGEN BY IARC, NTP OR OSHA.
TERATOGENICITY	NONE KNOWN
TOXICOLOGY SYNERGISTIC PRODUCTS	NONE KNOWN

PREVENTATIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT

GLOVES	RUBBER
RESPIRATORY	USE NISOH APPROVED DUST MASK IF DUSTY CONDITIONS EXIST.
CLOTHING	PROTECTIVE CLOTHING SHOULD BE WORN WHERE CONTACT IS UNAVOIDABLE.
OTHER	HAVE ACCESS TO EMERGENCY EYEWASH.

PREVENTATIVE MEASURES (CONT.)

ENGINEERING CONTROLS	NOT NECESSARY UNDER NORMAL CONDITIONS, USE LOCAL VENTILATION IF DUSTY CONDITIONS EXIST.
SPILL OR LEAK RESPONSE	CLEAN UP SPILLS IMMEDIATELY, PREVENT FROM ENTERING DRAIN. USE ABSORBANTS AND PLACE ALL SPILL MATERIALS 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

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

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

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

BRIGHT DYES
Division of Kingscote Chemicals

WATER TRACING DYE
FLT YELLOW/GREEN PRODUCTS

TECHNICAL DATA BULLETIN

Bright Dyes Yellow/Green products are specially formulated versions of Xanthene dye, certified by NSF International to ANSI/NSF Standard 60 for use in drinking water. This dye is the traditional fluorescent water tracing and leak detection material and has been used for labeling studies from the beginning of the century. It may be detected visually, by UV light and by appropriate fluoremetric equipment. Today it is most often used visually. This dye has been used by the military to mark downed pilots for search and rescue operations over large water bodies. Visually the dye appears yellow/green, depending on its concentration and under UV light as lime green.

Based on biochemical oxygen demand (BOD) studies, the dye is biodegradable with 65% of the available oxygen consumed in 7 days. The dye is resistant to absorption on most suspended matter in fresh and salt water. However, compared to Bright Dyes FWT Red products it is significantly less resistant to degradation by sunlight and when used in fluoremetry, stands out much less clearly against background fluorescence. As always the suitability of these products for any specific application should be evaluated by a qualified hydrologist or other industry professional.

General Properties	Tablets	Liquids	Powders
Detectability of active ingredient [1]	Visual <100 ppb	Visual <100 ppb	Visual <100 ppb
Maximum absorbance wavelength [2]	490/520 nm	490/520 nm	490/520 nm
Appearance	Orange convex 1.6cm diameter	Reddish, brown aqueous solution	Orange fine powder
NSF (Max use level in potable water)	6.0 ppb	10.0 ppb	1.0 ppb
Weight	1.35 gms ± 0.05		
Dissolution Time [3]	50% < 3 minutes 95% < 6 minutes		50% < 3 minutes 95% < 6 minutes
Specific Gravity		1.05 ± 0.05 @ 25° C	
Viscosity [4]		1.8 cps	
pH		8.5 ± 0.5 @ 25° C	

Coverage of Products	One Tablet	One Pint Liquid	One Pound Powder
Light Visual	605 gallons	125,000 gallons	1,200,000 gallons
Strong Visual	60 gallons	12,500 gallons	120,000 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.

Kingscote Chemicals, 3334 S. Tech Blvd., Miamisburg, Ohio 45342
Telephone: (937) 886-9100 Fax: (937) 886-9300 Web: www.brightdyes.com

BRIGHT DYES
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.

[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.

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

Characterization of fluorescence background in dye tracing. CC Smart, KC Karunaratne, *Environmental Geology*, **42**: 492, 2002. DOI: 10.1007/s00254-001-0510-y

Transient storage assessments of dye-tracer injections in rivers of the Willamette Basin, Oregon. A Laenen, KE Bencala, *Journal of the American Water Resources Association*, **37**(2): 367-377, 2001.

Fluorometric procedures for dye tracing. JF Wilson, ED Cobb, FA Kilpatrick, *USGS TWRI*, Bk3 ChapA12, Revised 1986.

A review of the toxicity of twelve fluorescent dyes used for water tracing. PL Smart, *The National Speleological Society Bulletin*, **46**: 21, 1984.

An evaluation of some fluorescent dyes for water tracing. PL Smart, IMS Laidlaw, *Water Resources Research*, **13**(1): 15, 1976.

REACTIVITY & TRANSPORT IN FIELD CONDITIONS

An evaluation of two tracers in surface-flow wetlands: rhodamine-WT and lithium. FE Dierberg, TA DeBusk, *Wetlands*, **25**(1): 8-25, 2005.

Use of rhodamine water tracer in the marshland upwelling system. SD Richardson, CS Wilson, and KA Rusch, *Ground Water*, **42**(5): 678-688, 2004.

A continuous dye injection system for estimating discharge in snow-choked streams. M Russell, P Marsh, and C Onclin, *Arctic, Antarctic, and Alpine Research*, **36**(4): 539-554, 2004

Conservative and reactive solute transport in constructed wetlands. SH Keefe, LB Barber, RL Runkel, JN Ryan, DM McKnight, and RD Wass, *Water Resources Research*, **40**: W01201. 2004, doi:10.1029/2003WR002121.

Comparison of rhodamine WT and bromide in the determination of hydraulic characteristics of constructed wetlands. AY-C Lin, J-F Debroux, JA Cunningham, and M Reinhard, *Ecological Engineering*, **20**: 75-88, 2003, doi:10.1016/S0925-8574(03)00005-3.

Comparing transient storage modeling and residence time distribution (RTD) analysis in geomorphically varied reaches in the Lookout Creek basin, Oregon, USA. MN Gooseff, SM Wondzell, R Haggerty, and J Anderson, *Advances in Water Resources*, **26**(9): 925-937, 2003.

Evaluation of tracer tests completed in 1999 and 2000 on the Upper Santa Clara River, Los Angeles and Ventura Counties, California. MH Cox, GO Mendez, CR Kratzer, EG Reichard, *US Geological Survey Water-Resources Investigations Report*, 03-4277, 2003, http://pubs.usgs.gov/wri/wrir034277/.

Description of flow through a natural wetland using dye tracer tests. DA Stern, R Khanbilvardi, JC Alair, W Richardson, *Ecological Engineering*, **18**(2): 173, 2001.

Limitations and potential of commercially available rhodamine WT as a groundwater tracer. DJ Sutton, ZJ Kabala, A Francisco, D Vasudevan, *Water Resources Research*, **37**(6): 1641, 2001.

The use of photolytic rhodamine WT and sulpho G as conservative tracers of dispersion in surface waters. RC Upstill-Goddard, JM Suijlen, G Malin, PD Nightingale, *Limnology and Oceanography*, 46(4): 927, 2001.

Tracer-grade rhodamine WT: structure of constituent isomers and their sorption behavior. D Vasudevan, RL Fimmen, AB Francisco, *Environmental Science and Technology*, **35**(20): 4089, 2001.

Tracer-grade rhodamine WT: structure of constituent isomers and their sorption behavior. D Vasudevan, RL Fimmen, AB Francisco, *Environmental Science and Technology*, **35**(20): 4089, 2001.

Sorption and intraparticle diffusion of fluorescent dyes with consolidated aquifer media. DA Sabatini, *Ground Water*, **38**: 651, 2000.

Numerical model of a tracer test on the Santa Clara River, Ventura County, California. T Nishikawa, KS Paybins, JA Izbicki, EG Reichard, *Journal of the American Water Resources Association*, **35**(1): 133-141.

Fluorescent dye and media properties affecting sorption and tracer selection. T Kasnavia, D Vu, DA Sabatini, *Ground Water*, **37**(3): 376, 1999.

Dye adsorption in a loam soil as influenced by potassium bromide. SE Allaire-Leung, SC Gupta, JF Moncrief, *J Environmental Quality*, **28**: 1831, 1999.

Evaluation of rhodamine WT as an adsorbed tracer in an agricultural soil. CJ Everts, RS Kanwar, *Journal of Hydrology*, **153**: 53, 1994.

Cosolvency effects on sorption of a semipolar, ionogenic compound (Rhodamine WT) with subsurface materials. TS Soerens, DA Sabatini, *Environmental Science and Technology*, **28**: 1010, 1994.

Potentials of photolytic rhodamine WT as a large-scale water tracer assessed in a long-term experiment in the Loosdrecht lakes. JM Suijlen, J J Buyse, *Limnology and Oceanography*, **39**(6):141, 1994.

Influence of rhodamine WT properties on sorption and transport in subsurface media. BJ Shiau, DA Sabatini, JH Harwell, *Ground Water*, **31**: 913, 1993.

Characteristics of rhodamine WT and Fluorescein as adsorbing ground-water tracers. DA Sabatini, TA Austin, *Ground Water*, **29**: 341, 1991.

Submersed plants and algae as factors in the loss of rhodamine WT dye. EG Turner, MD Netherland, KD Getsinger, *J Aquat Plant Manage*, **29**: 113, 1991.

Fluorescent dyes: a search for new tracers for hydrology. ML Viriot, JC Andre, *Analusis*, **17**: 97, 1989.

Tracing ground-water movement in abandoned coal mined aquifers using fluorescent dyes. PJ Aldous, PL Smart, *Ground Water*, **26**: 172, 1988.

Photolysis of rhodamine-WT dye. DY Tai, RE Rathbun, *Chemosphere*, **17**(3): 559, 1988.

Practical aspects of tracer experiments in acidic, metal enriched streams. GW Zellweger, KE Bencala, DM McKnight, RM Hirsch, BA Kimball, In *USGS OFR 87-764*, 125, 1988.

Soil water dye tracing, with special reference to the use of rhodamine WT, lissamine FF and amino G acid. ST Trudgill, *Hydrological Processes*, **1**: 149, 1987.

The stability of rhodamine WT dye in trial studies of solute transport in an acidic and metal-rich stream. KE Bencala, DM McKnight, GW Zellweger, J Goad, In *USGS WSP 2310*, 87, 1986.

Rhodamine WT dye losses in a mountain stream environment. KE Bencala, RE Rathbun, AP Jackman, VC Kennedy, GW Zellweger, and RJ Avanzino, *Water Resources Bulletin*, **19**(6): 943, 1983.

Use of tracers to confirm ground-water flow. DB Aulenbach, JH Bull, BC Middlesworth, *Ground Water*, **16**: 149, 1978.

SAMPLING AND ANALYSIS

Detection of fluorescent compounds in the environment using granular activated charcoal detectors. C Smart, B Simpson. *Environmental Geology*, **42**: 538, 2002. DOI: 10.1007/s00254-001-0517-4

Capillary electrophoresis/laser-induced fluorescence in groundwater migration determination. WC Brumley, ClL Gerlach, American Laboratory, January, 1999. http://www.iscpubs.com/articles/entireal.html.

Analysis of fluorescent water tracers using on-line pre-concentration in Micro HPLC. REJ Van Soest, JP Chervet, M Ursem, JM Suijlen, *LC-GC International*, **9**(9): 586, 1996.

A HPLC-based detection method for fluorescent sea water tracers using on-line solid phase extraction. JM Suijlen, W Staal, PM Houpt, A. Draaier, *Continental Shelf Research*, **14**(13/14): 1523, 1994.

Identification and separation of water tracing dyes using pH response characteristics. R.G. Lyons, Journal of Hydrology, **152**: 13-29, 1993.

Determination of rhodamine WT in surface water by solid-phase extraction and HPLC with fluorescence detection. JW Hofstratt, M Steendijk, G Vriezekolk, W Schreurs, GJAA Broer, N Wijnstok, *Water Research*, **25**: 883, 1991.

Analytical problems arising from the use of bromide and rhodamine WT as co-tracers in streams. DR Jones, RF Jung, *Water Research*, **24**: 125, 1990.

A procedure for enriching and cleaning up rhodamine B and rhodamine WT in natural waters, using a Sep-pak C18 cartridge. RWPM Lane, MW Manuels, W Staal, *Water Research*, **18**: 163, 1984.

AQUATIC EFFECTS

Toxicological and ecotoxicological assessment of water tracers. H Behrens, U Beims, H Dieter, G Dietze, T Eikmann, T Grummt, H Hanisch, H Henseling, W Käß, H Kerndorff, C Leibundgut, U Müller-Wegener, I Rönnefahrt, B Scharenberg, R Schleyer, W Schloz, and F Tilkes, *Hydrogeology Journal*, **9**:321-325, 2001

An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing. MS Field, RG Wilhelm, JF Quinlan, TJ Aley, *Environmental Monitoring and Assessment*, **38**: 75, 1995.

Effects of rhodamine water tracer on Escherichia Coli densities. M Jensen, KK Kristennsen, *Water Research*, **23**: 257, 1989.

NITROSAMINE FORMATION

Potential for nitrosamine formation in seven fishery chemicals. SL Abidi, VK Dawson, RC Huber, *The Progressive Fish-Culturist*, **48**: 301, 1986.

Investigation of the possible formation of diethylnitrosamine resulting from the use of rhodamine WT dye as a tracer in river waters. TR Steinheimer, SM Johnson, *USGS WSP 2290*, 37, 1986.

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

Bulletin No. 103
Fluorescein

INTRODUCTION

Fluorescein was the first fluorescent dye used for water tracing work[1] and is still used for qualitative (visual) studies of underground contamination of wells. In recent years, Rhodamine WT has almost completely replaced fluorescein for flow measurements[2] and circulation, dispersion, and plume studies[3]. Nonetheless, fluorescein has a role in such studies, and can be used for masking, hydraulic model studies, and underground water studies.

ADVANTAGES

Fluorescein has the following advantages over other tracer dyes:

- Its low sorption rate is far better than Rhodamine B, and comparable to Rhodamine WT.
- It has a temperature coefficient of only –0.36% per degree C, about one-eighth of the temperature coefficient of rhodamine dyes[2,4].
- It emits a brilliant green fluorescence, which gives an excellent visual or photographic contrast against the backgrounds normally encountered in water transport studies. Therefore it is easy to visualize the progress of an experiment.
- It is more aesthetic than the red dyes. This is psychologically important, especially in ocean areas subject to the blooms of certain dinoflagellates, called "red tides." Less public resistance will be encountered using a dye that does not resemble red tide[5].

DISADVANTAGES

Fluorescein has been replaced by other dyes, principally Rhodamine WT, for the following reasons:

- It is rapidly destroyed by sunlight. Reference 4 reports that a 50% loss occurred in three hours of sunlight exposure, with dye being held in an Erlenmeyer flask. Other tests in an flat, uncovered Pyrex dish showed an almost complete destruction in two hours[6].
- Many naturally occurring fluorescent materials have similar characteristics and thus interfere with measurement. When carefully chosen optical filters are used, the situation is better than that reported in Reference 4, but higher concentrations are required to overcome the effect of higher and more variable "blank" fluorescence.
- Fluorescein is more pH-sensitive than rhodamine dyes. Fluorescence drops very sharply at pH values below 5.5. For optimum results, pH should be between 6 and 10.

MASKING TECHNIQUES

In river, harbor, and ocean tests, fluorescein can be used to mask the objectionable color of the rhodamine dyes. Tests show that Fluorescein is an effective mask, subject to the following conditions[6]:

- The concentration of fluorescein should be at least five times that of the active ingredients in the Rhodamine B or Rhodamine WT concentrate.
- Where the receiving water is shallow, clear, and in full sunlight, the dyes must be dispersed quite rapidly. With slow dispersion, the photosensitive fluorescein will be destroyed before the masking effect is complete.
- Masking is subjective. Lower (hence less costly) amounts of fluorescein may be effective, depending on water clarity, bottom color, wave action, etc. Small scale addition of the mixed dyes to the receiving water should be made in advance

of a large scale test. This test should be made on a bright sunny day, if possible.

- Note that fluorescein is not the ingredient measured. The optical filter and light source in the fluorometer read only rhodamine dye[7].

HYDRAULIC MODEL STUDIES

Fluorescein may be used in hydraulic model studies in exactly the same way that Rhodamine WT is used (See Refs. 2 and 3 for details).

The major advantage of using fluorescein is its visibility; the green color can be seen as the test proceeds. The major disadvantage is fluorescein's light sensitivity. It can be destroyed by light entering the test area, both from windows and from indoor lights, especially fluorescent ones.

Containers used for dye destruction tests must be transparent to light at shorter wavelengths. Clear borosilicate glass baking pans are handy, since they transmit light at shorter wavelengths than window glass or the glass envelopes of fluorescent lamps.

Test samples must be at low concentrations (around 0.2 PPM) so that the fluorescein in the bottom of the pan is not protected from the incident light by absorption of the fluorescein in the top of the pan.

In certain cases, deliberate destruction of the fluorescein by sunlight may be a convenience instead of a problem. Hydraulic models often recycle water. With the very stable Rhodamine WT, the concentration of dye in the entire system will build up over a sequence of several tests, requiring replacement of the water. If a shallow holding tank can be placed outdoors, the degradation of fluorescein by sunlight may eliminate the need to replace the water.

UNDERGROUND WATER STUDIES

Fluorescein can be used quantitatively for underground tests, subject to limitations imposed by the higher background of naturally occurring fluorescent materials.

An advantage of fluorescein in underground studies is its light sensitivity. Should it reach an open receiving body of water, the color will be less of a problem because it will disappear rapidly in the sunlight.

FILTER AND LIGHT SOURCE SELECTION

Using fluorescein, the following light sources and filters are recommended (referenced part numbers are specific to Turner Designs products):

	10-AU-005
Optical Kit	10-086 (Lamp and all filters are included in this kit.)
Light Source	10-089 Blue Lamp
Reference	10-063
Excitation	10-105
Emission	10-109R-C

We have found that background fluorescence can be very high in natural systems with the fluorescein setup. In most cases, this background should be adequately suppressed using the 10-AU fluorometer. If, however, background cannot be suppressed, a mask (attenuator) may be added to the excitation filter holder to reduce its diameter and the amount of light scatter. Attenuation by a factor of 5 can be obtained with the 10-318R Attenuator Plate.

Fluorescein, known as "Acid Yellow 73", "Acid Yellow T", "DNC Yellow 7", etc., can be obtained from the following sources (addresses checked and confirmed June 1996):

Pylam Products
Company, Inc.
1001 Stewart Avenue
Garden City, NY 11530
516/222-1750

Tricon Colors, Inc.
16 Leliarts Lane
Elmwood Park, NJ 07407
201/794-3800

LISSAMINE FF

The properties of uses of Lissamine FF are reported in Reference 9. Its spectral characteristics are similar to those of fluorescein, but it does not decompose as rapidly in sunlight. Use the fluorescein filters detailed above with Lissamine FF. Pylam Products (address shown above) offers

Lissamine FF as "Brilliant Acid Yellow 8G" or "Brilliant Sulphoflavine FFA".

REFERENCES

1) Dole, R. B., *Use of Fluorescein in the Study of Underground Waters*, USGS Water Supply Paper 160, 73-85 (1906).

2) *A Practical Guide to Flow Measurement*, monograph by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.

3) *Circulation, Dispersion, and Plume Studies*, monograph by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.

4) (0047) Feuerstein, D.L., Sellick, R.E., *Fluorescent Tracers for Dispersion Measurements*, Journal of Sanitary Engineering, ASCE 89 (SA4), 1-21 (1963).

5) (0031) Murakami, Ken, Water Quality Section, Water Quality Control Division, Public Works Research Institute, 5-41-7, Shimo, Kita-Ku, Tokyo, 115, personal communication.

6) Turner Designs Laboratory Tests conducted July 23, 1975.

7) "Filter Selection Guide" for Turner Designs Fluorometers, by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.

8) (0413) Smart, P.L., Laidlaw, I.M.S., An *Evaluation of Some Fluorescent Dyes for Water Tracing*, Water Resources Research, 13 (1), 15-33 (1977).

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