Broadwater Assimilative Capacity Study Dye Release

GRIFFITH CENTRE FOR COASTAL MANAGEMENT
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GRIFFITH CENTRE FOR COASTAL MANAGEMENT Griffith University Gold Coast Parklands Drive SOUTHPORT QLD 4215 PMB 50 Gold Coast Mail Centre 9726 Telephone (07) 55528506 Facsimile (07) 55528067 www.gu.edu.au/centre/gccm/	***Document:*** Griffith Centre for Coastal Management Research Report No. 72 ***Project:*** Broadwater Assimilative Capacity Study ***Title***: *Broadwater Assimilative Capacity Study Dye Release* ***Project Leader***: Rodger Tomlinson ***Author(s)***: Lawrence Hughes Hamid Mirfenderesk Rodger Tomlinson ***Sponsoring Organisation*****:** Gold Coast Water ***Contact***:: Sayedur Khan

Synopsis: In order to verify the dispersion and advection co-efficients of the Mike21 hydrodynamic model of the Broadwater study area, a series of rhodamine dye release studies where undertaken. This report describes the operational systems and the results of these experiments.

Keywords: Hydrodynamic modelling, Gold Coast, Broadwater, Data Collection, Rhodamine dye, diffusion, advection.

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1 INTRODUCTION

This report presents the results of a novel method to measure advection and dispersion at various locations within the Broadwater; a semi-tropical coastal lagoon located between latitudes 27.98-27.75S and longitudes 153.39-153.43E, in the state of Queensland, Australia. This water body is connected to the Pacific Ocean through a heavily modified tidal entrance named The Gold Coast Seaway. The initial proposal is detailed in the Griffith Centre for Coastal Management Report No 65.

The study aims to investigate transport processes within the Broadwater through measuring the advection-dispersion coefficients of the estuary, which are a function of characteristics of the water body.

Traditionally advection-dispersion models have been verified by monitoring the dispersion characteristics of a highly concentrated tracer dye (Rhodamine WT) placed into the water body to be studied. This methodology has a number of disadvantages:

- The initial bright red dye concentration can cause concern to bystanders leading to undue negative community reaction.
- The dispersion effects of the vessel monitoring the dye concentration levels can be excessive, particularly as small changes made during the early stages of the study can compound to be large effects later.
- Rhodamine dye has a density of 1.03 at 25° C and tends to float on the surface thus not giving true 3D dispersal representation.

The proposed system aims to

- Deliver a controlled low-level release of rhodamine dye at 1 metre depth with a density similar to the surrounding water body.
- Establish a dye plume fixed in space and time that can be monitored in near real-time with minimal effect of the recording vessel.
- Present the results to enable verification of the advection co-efficient and dispersion co-efficient used in the MIKE21 Model.

To this end, this report describes the methodology used for the dye release experiment and explains a number of initiatives, which were undertaken for more effective data collection and presentation.

Final results are condensed into a table giving the rate and concentration of the dye released at source and dye concentrations at various locations measured *in-situ*. These values can be factored into the Broadwater Assimilative Capacity model to verify the advection co-efficient and dispersion co-efficient being used are correct. The discussion of the advection – dispersion model calibration using these data is presented in a separate report.

1.1 Objectives

The purpose for the data collection program for this study is to:

Develop a dye release system that reduces the quantities of dye being added to the environment and minimises the effects of the survey vessel on the released dye plume.
Provide dye concentration values that can be used to determine advection co-efficient and dispersion co-efficient for inclusion in the Broadwater Assimilative Capacity Model.

2 OPERATIONS PROTOCOL

Traditionally in the past, highly concentrated non-toxic dye was released, as a patch into a water body and concentrations recorded until the dye was so diluted it was impossible to see with the naked eye.

Disadvantages with this system are

1. The concentrated dye is very noticeable throughout the experiment,
2. Positioning of the study area is determined by advection of the prevailing current conditions
3. The boat being used to collect the samples can often affect the dispersion characteristics of the body of water under investigation.

The system being proposed in this application has many novel approaches to minimise the disadvantages of the older system.

Using a continuous discharge:

1. Lower concentrations of the dye can be used as the location of the dye plume is fixed in time and space,
2. Recent advances in instrumentation enable lower concentrations to be monitored in near real-time,
3. As the plume position is fixed, boat passage through the experimentation area should have a minimal effect on the dispersion characteristics.

2.1 Required Resources

Resource requirement for the implementation of this data collection program includes:

1. A boat to provide a stable platform to assemble the dye mixing station, with stand–alone power supply plus an ADCP to measure current velocities and direction.
2. A second boat fitted with DGPS, stand-alone power supply and a YSI multi parameter sonde capable of measuring rhodamine dye concentrations within the plume.
3. Sampling equipment to enable laboratory analysis of dye concentrations to verify the *in-situ* field measurements.
4. Release drogues to indicate the plume location and to give estimates on advection.

3 PROPOSED STUDY AREAS

The driver for this study is the need for the release of larger quantities of re-cycled water, resulting from the growth of the city, at the Gold Coast Seaway. Currently almost all treated re-cycled water of the city is released at the Seaway during an outgoing ebb tide. The modelling exercise aims to provide a better understanding on:

- What would be the concentration of pollutants at the Broadwater if the release time and volume of the pollutants are increased?
- Wether the released pollutant will return into the estuary during the next tidal cycle and if so what would be the impact.
- Possibility of pollutant release optimisation to maximise the capacity of the system.

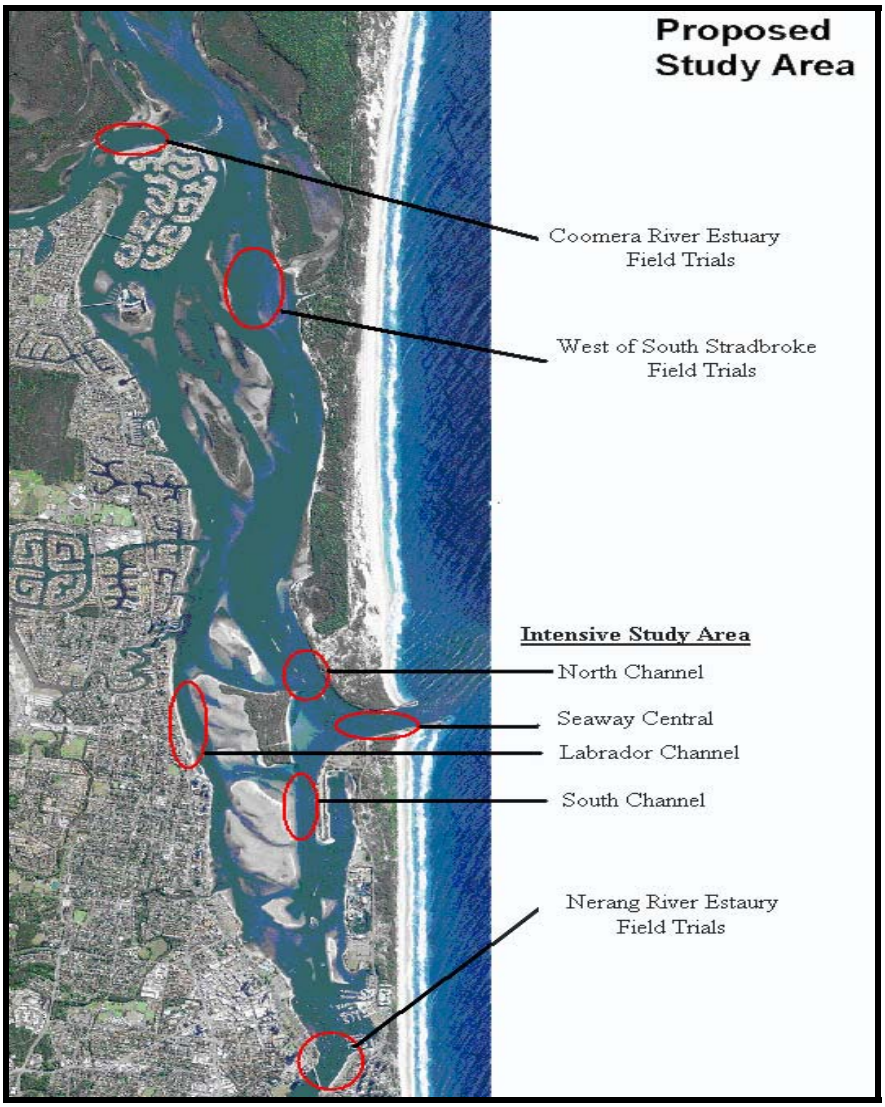


Figure 1 - The Broadwater

3.1 Intensive Study Area

The area, which is regarded as critical to this study, is the Gold Coast Seaway. The outlying areas can be used to verify larger scale models but for this report the North Channel, South Channel, the Seaway and the Labrador Channel have been highlighted. (Figure 2)

Figure 2 – Gold Coast Seaway showing Locations and Dates

3.2 Field Trials

Field trails were undertaken to prove the viability of the system. Dye concentration levels, flow rates and sampling speeds were investigated in an area West of South Stradbroke Island and secondary trials were undertaken at the mouth of the Nerang River to practise operational procedures and to demonstrate the system to the press and interested third parties. A third set of field trials was completed in the Coomera River estuary to investigate improvements to the system presented in this paper. (Figure 1)

4 METHODOLOGY

A platform is fixed in position carrying a pump/dye mixing system developed by the Griffith Centre for Coastal management.

Clean seawater is pumped through the system enabling flow rates to be calibrated and system checks to be completed.

Once the system is operational, a container large enough to complete a 60 minute plume study is filled with dye diluted to the correct concentration, around 40 ppm, and allowed to flow into the system giving a dye volume of 4 l/s discharged at velocity of 0.5 m/s at a concentration of approximately 1 ppm, i.e. a strong pink colour.

A sample is taken at the outlet pipe every 12 minutes to ensure dye concentration is uniform over the survey period and to calculate flow rate parameters.

A second vessel with a Rhodamine dye sensor tracks the dye plume and released drogues taking samples where high rhodamine levels are encountered. Positions are recorded using differential satellite positioning equipment.

After 60 minutes the pumping system is switched off leaving the survey area to return to a clean seawater condition.

The experiment is then repeated at a later date enabling dispersion and advection parameters to be calculated for flood and ebb tidal conditions.

During the field trials, background fluorescent measurements were found to be variable, ranging from –3 μg/l to 4 μg/l depending on the water body, calibration zero values used and the sampling rate of the YSI 6600. As the DGPS logging rate was 5 seconds a high band pass filter was incorporated by setting the YSO logging rate to 1 hertz and recording the rhodamine maximum encountered in each 5 sec interval.

Field trials also indicated that if the survey vessel travelled faster than 0.9 m/s erroneous values caused by turbulence at the pipe intake were produced. During post processing a filter was introduced to remove any values where the survey vessel is in excess of 0.9 m/s.

The narrow nature of the dye plume produces a large number of low values recorded near the plume. For clarity of presentation, a second high band pass filter was introduced that removes these lower rhodamine values. (Rh < 4.2118 Ln (-0.0065 * source distance).)

4.1 Equipment

4.1.1 Dye Dispersion System

A stable platform is fixed in position carrying a pump/dye mixing system and a Sontek 1.5 MHz ADCP (Appendix A) recording water velocities and direction throughout the survey period.

Clean seawater is pumped through the mixer box (figures 3+4) enabling the flow rate to be adjusted to around 4 L/s giving a discharge flow of 0.5 m/s through a 150 mm diameter discharge pipe placed 1 metre below the surface.

Releasing the first marker drogue into the water starts the survey and a 2.5 litre container filled with 40-ppm dye concentrate is allowed to flow into the mixer box (Figure 3). A restricted nozzle ensures uniform flow and a sample is taken for later verification of dye concentration, nominally 1.5 ppm. Every twelve minutes a drogue is released and a sample taken from the mixer box. The discharge is terminated after the release of the 6th marker drogue, sixty minutes after the start.

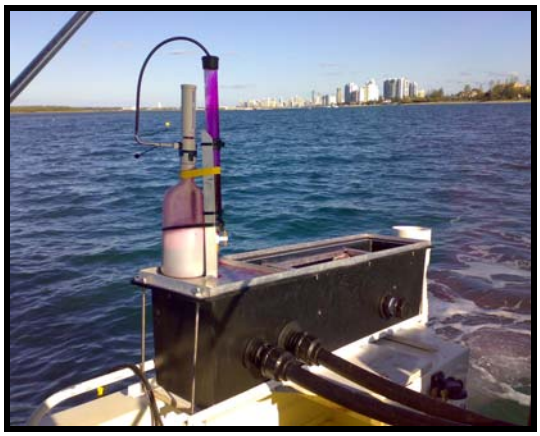


Figure 3 Weir and Mixer Box

Figure 4 Fire-fighter Pump

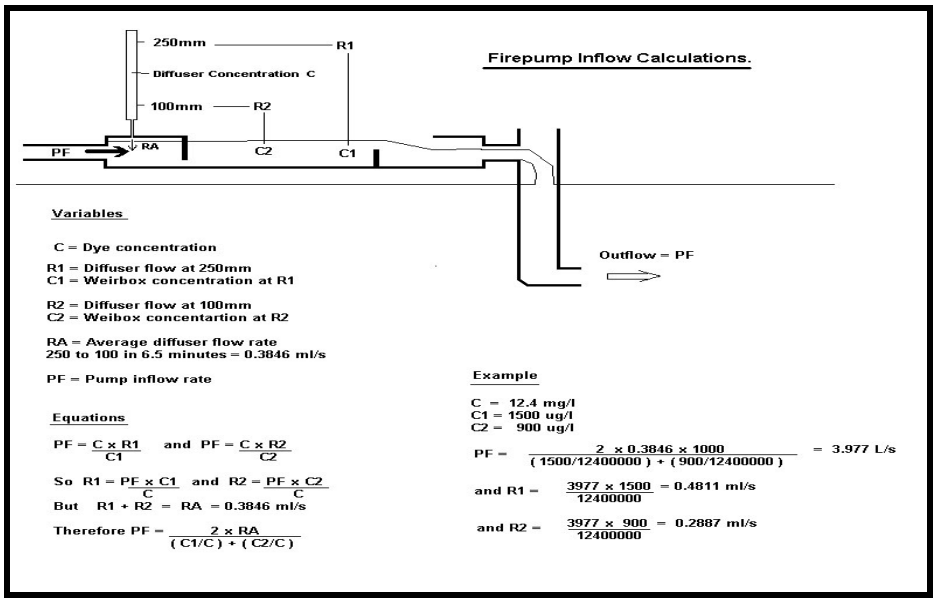


Figure 5 Dye Mixer Box Schematic

4.1.2 Dye Concentration Monitoring System

A second vessel fitted with a differential GPS system (Appendix B) and a multi-parameter YSI 6600 probe (Appendix C) connected to a YSI flow cell measures and records rhodamine, turbidity, temperature and conductivity.

Whilst underway, water is pumped to the instrument using a diaphragm pump via a reinforced tubing with an inlet located 1 metre below the surface. The vessel speed was kept below 1 m/s to give good positional accuracy and to minimise false spikes caused by turbulence and air entrainment at the pipe inlet.

The near real-time presentation of the data on the survey vessel enabled field samples to be taken during high rhodamine concentrations for later analysis in a laboratory to confirm the field values being recorded.

Figure 6 Survey vessel and Water Inlet Pipe

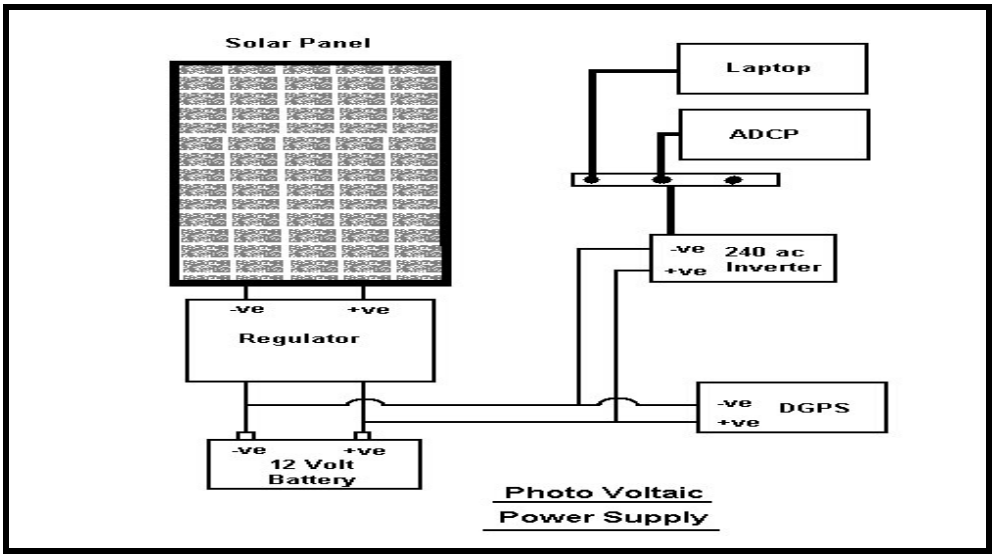


Figure 7 Boats Power Supply System

4.2 Drogue Tracking

Two drogue types were used for the survey, a 50 mm x 250 mm concrete and foam filled pvc pipe for surface currents and a larger 120 mm x 1000 mm foam filled pvc pipe with an aluminium vane set at 1 metre below the surface. (Figure 8).

Waypoints were recorded using a handheld Garmin GPS 76 and plotted using OzyExplorer software onto a Google Earth jpeg aerial image.

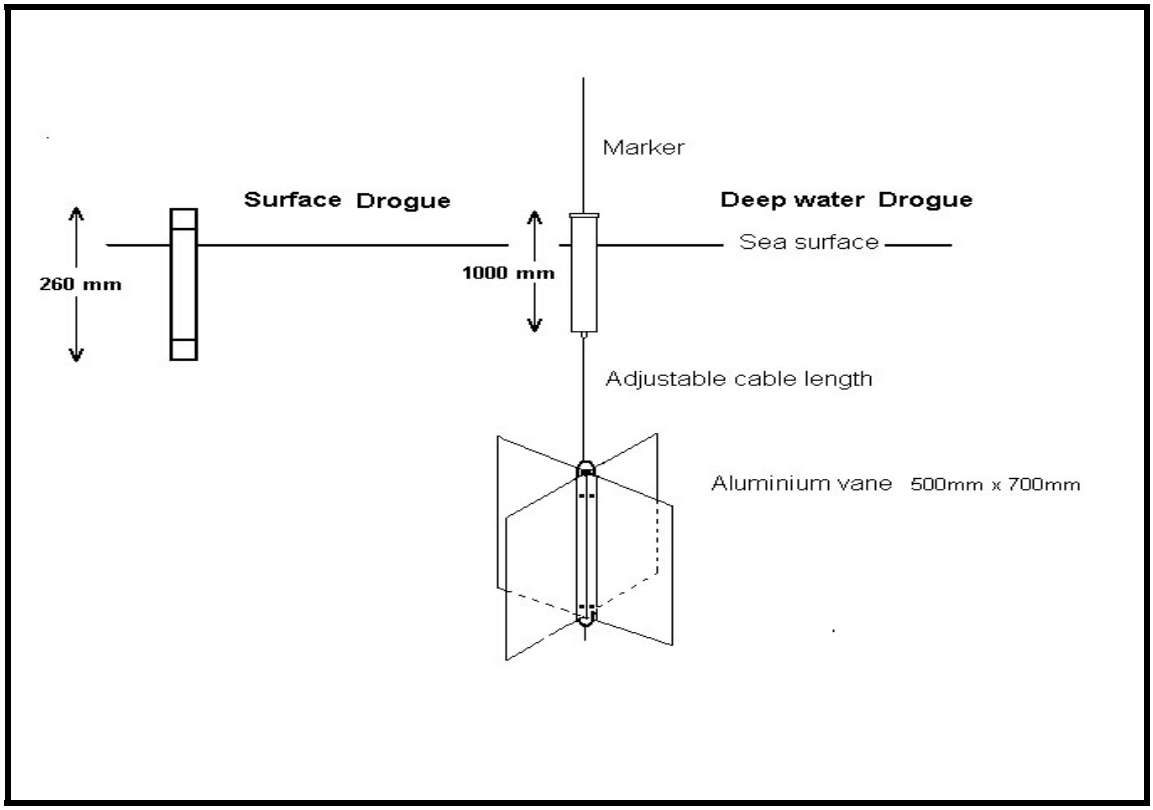


Figure 8 Drogue Designs

4.3 Tidal Predictions

Tidal predictions were calculated for the survey period using wxtide32 software with Gold Coast Seaway as the reference port, http://wxtide32.com. (Figure 9)

4.4 Weather Data

Regular downloads were taken from the Bureau of Meteorology Gold Coast Seaway field station. (http://www.bom.gov.au/products/IDQ65119/IDQ65119.94580.shtml)

4.5 Time scheduling

Time scheduling was dictated by the tidal predictions with weather forecasts factored in daily.

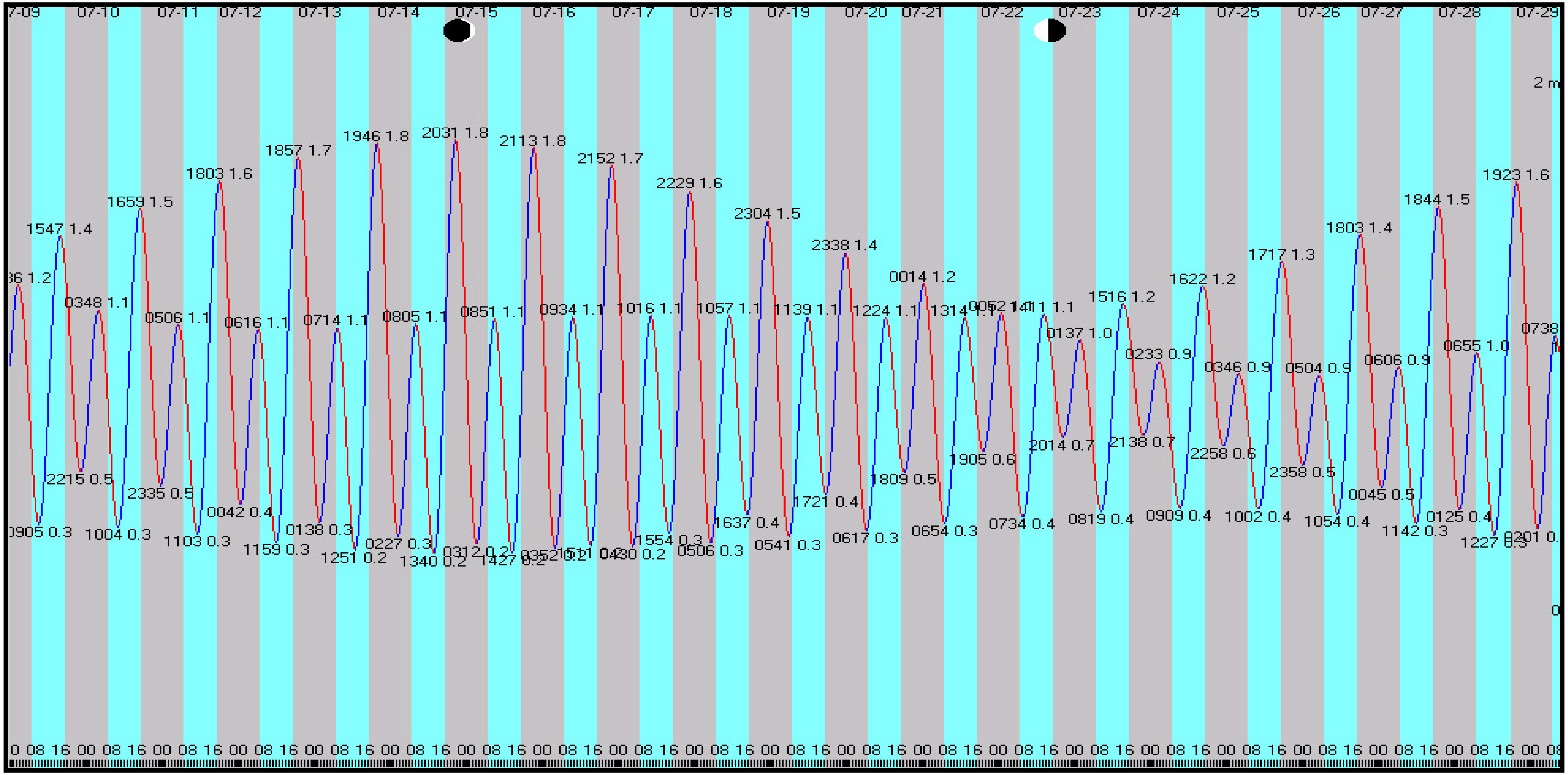


Figure 9 Tidal Predictions for the Gold Coast Seaway

5 RESULTS

5.1 Tabulated Statistics

Table 1

Physical Water and Weather Parameters

Date	Location	Eastings	Northings	Wind Speed	Wind Direction	Flood or Ebb	Tidal Range		Current Speed	Current Direction
dd/mm/yyyy		m	m	km/hr			time/ht	time/ht	m/s	deg N
10/07/2007	Seaway Central	541794	6910026	30-35	SSE - SE	Flood	10:04/0.3	16:59/1.5	0.24	244
11/07/2007	Seaway South	541395	6909355	19 - 22	SSE - SE	Flood	11:03/0.3	18:03/1.6	0.47	203
11/07/2007	Seaway North	541264	6910445	30	SE	Flood	11:03/0.3	18/03/1.6	1.07	300
17/07/2007	Seaway South	541257	6908475	17 - 24	N	Ebb	10:16/1.1	15:54/0.3	0.57	22
18/07/2007	Seaway North	540898	6911396	19 - 31	W - NNW	Ebb	10:57/1.1	16:37/0.4	0.56	162
20/07/2007	Labrador Channel	540203	6909719	11 - 20	ESE - SSE	Flood	06:17/0.3	12:24/1.1	0.27	306
20/07/2007	Labrador Channel	540059	6910413	24 - 28	SE - SSE	Ebb	12:24/1.1	18:09/0.5	0.31	191

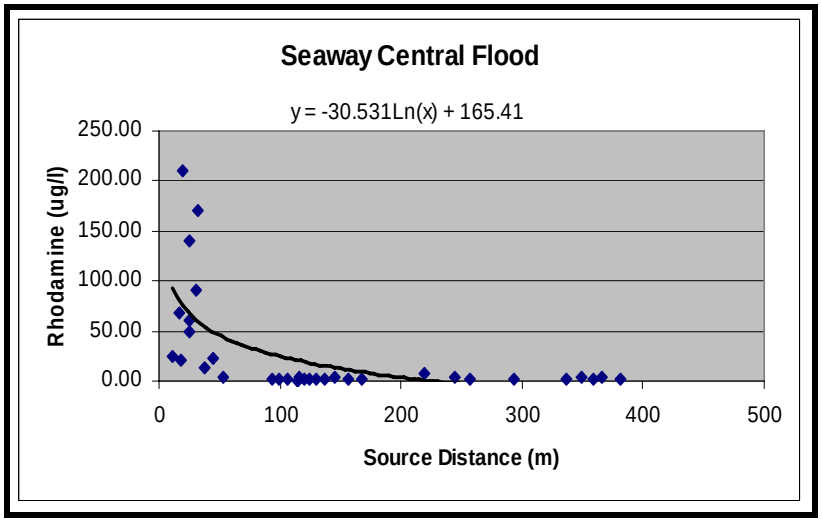
Table 2

Dye Concentration Statistics

Date	Location	Eastings	Northings	Start Time	Finish Time	Total time	Dye Concentrate	Dye used	250mm sample	100mm sample	dispenser rate	Release rate	Release concentration
dd/mm/yyyy		m	m	hh:mm	hh:mm	secs	mg/l	ml	ug/l	ug/l	ml/s	L/s	ug/l
10/07/2007	Seaway Central	541794	6910026	14:00	15:00	3600	13.76	950	1390	800	0.264	3.32	1095
11/07/2007	Seaway South	541395	6909355	13:36	14:36	3600	13.76	1350	2180	950	0.375	3.30	1565
11/07/2007	Seaway North	541224	6910506	15:24	16:14	2160	13.76	900	1566	950	0.417	4.56	1258
17/07/2007	Seaway South	541257	6908474	13:36	14:36	3600	12.65	1350	2120	960	0.375	3.08	1540
18/07/2007	Seaway North	540898	6911396	13:12	14:12	3600	12.33	1500	1940	570	0.417	4.09	1255
20/07/2007	Labrador Channel	540203	6909719	10:36	11:36	3600	12.59	1400	1711	730	0.389	4.01	1221
20/07/2007	Labrador Channel	540059	6910413	14:36	15:36	3600	10.56	1300	1280	880	0.361	3.53	1080

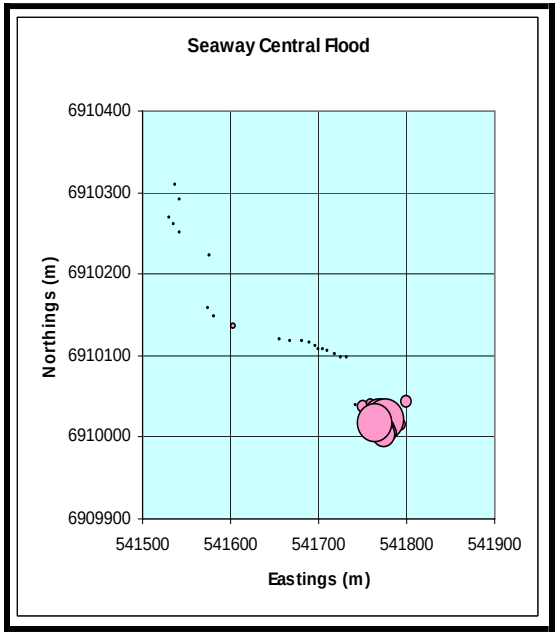
5.2 Intensive Study Results

Figure 10 Gold Coast Seaway Flood Tide



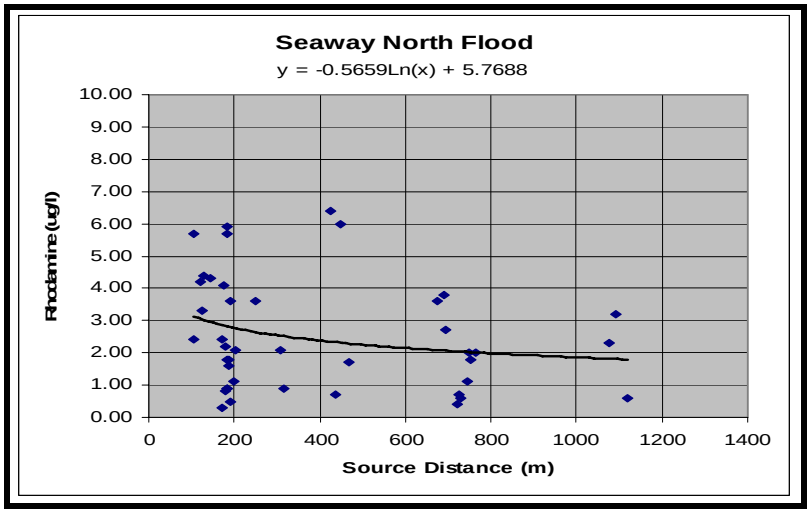
Rhodamine Levels and Distance from Source

Drogue Tracks and Location



Rhodamine Levels and Locations

Figure 11 Broadwater North Channel Flood Tide



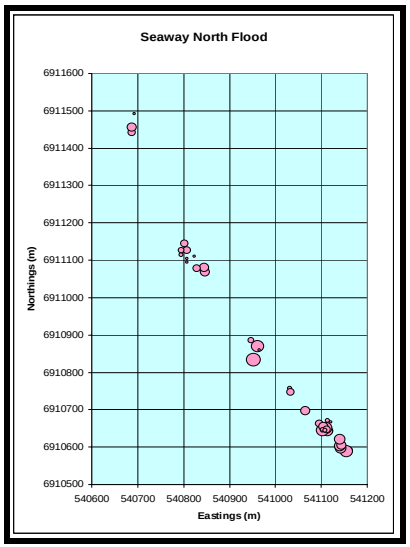
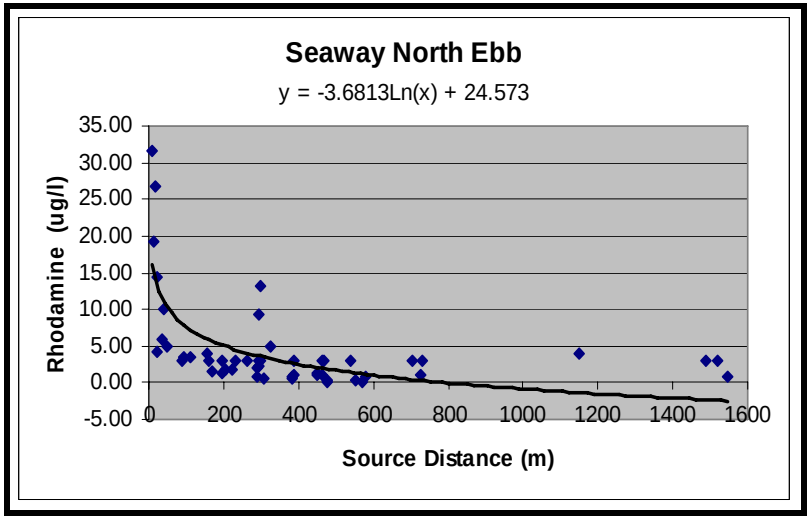
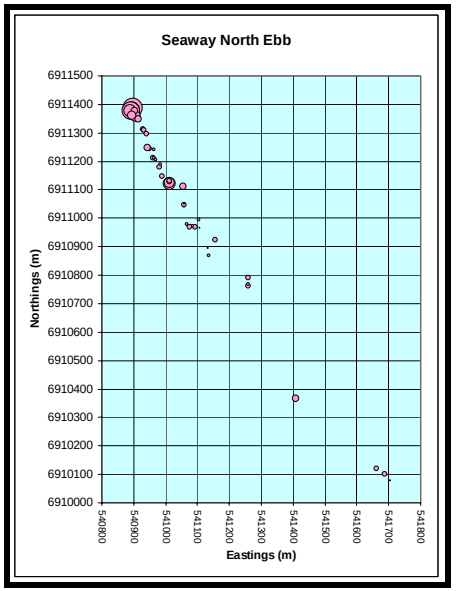


Figure 12 Broadwater North Channel Ebb Tide



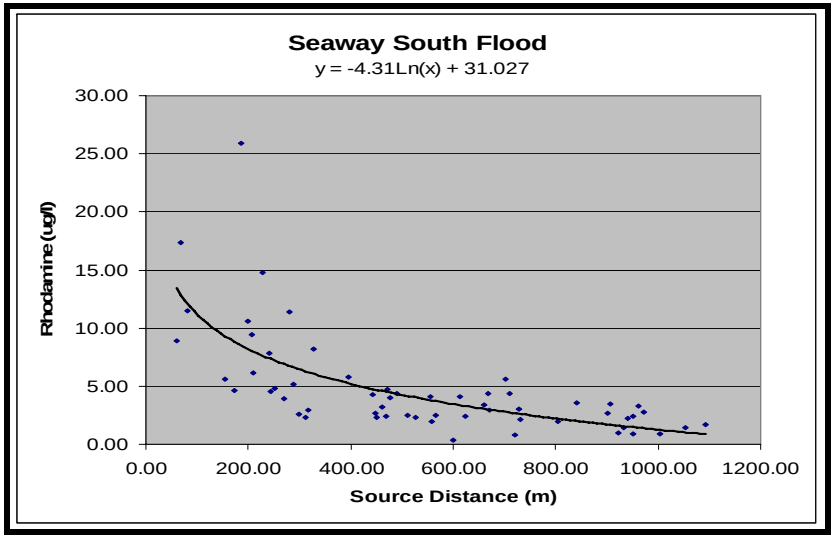


Rhodamine Levels and Distance from Source

Drogue Tracks and Location

Rhodamine Levels and Locations

Figure 13 Broadwater South Channel Flood Tide



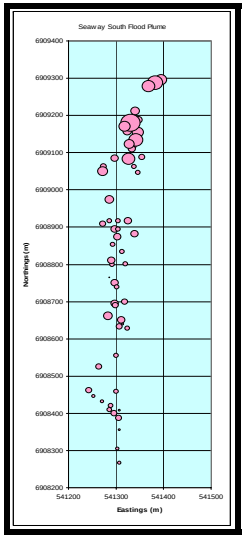
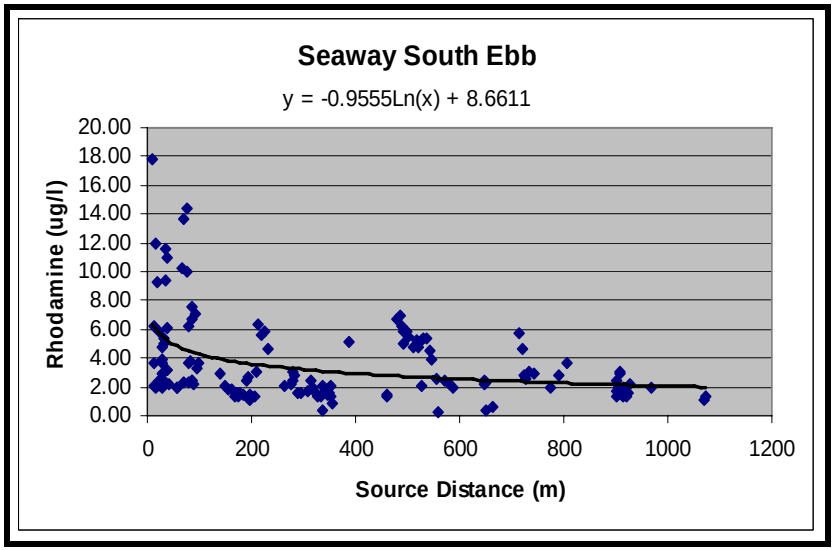
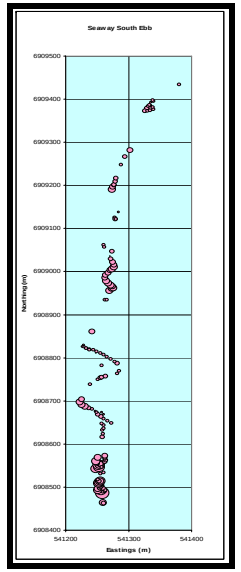


Figure 14 Broadwater South Channel Ebb Tide



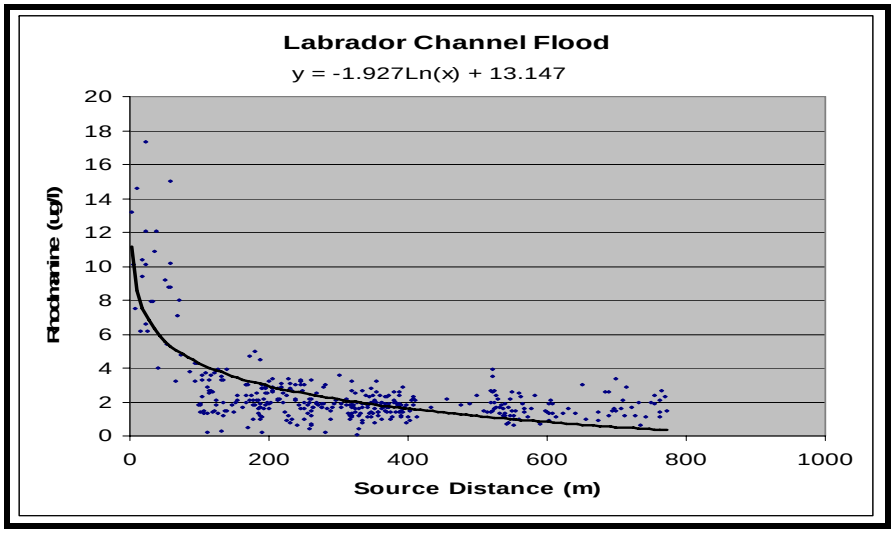


Rhodamine Levels and Distance from Source

Drogue Tracks and Location

Rhodamine Levels and Locations

Figure 15 Labrador Channel Flood Tide



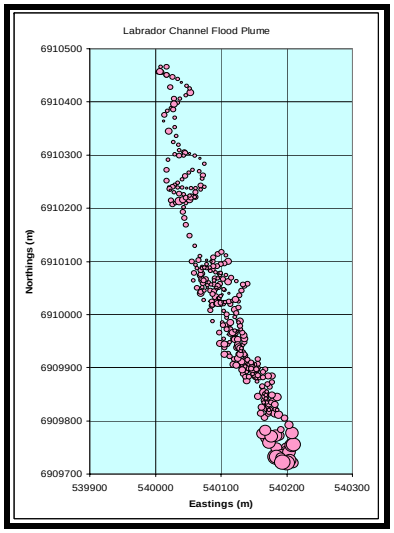
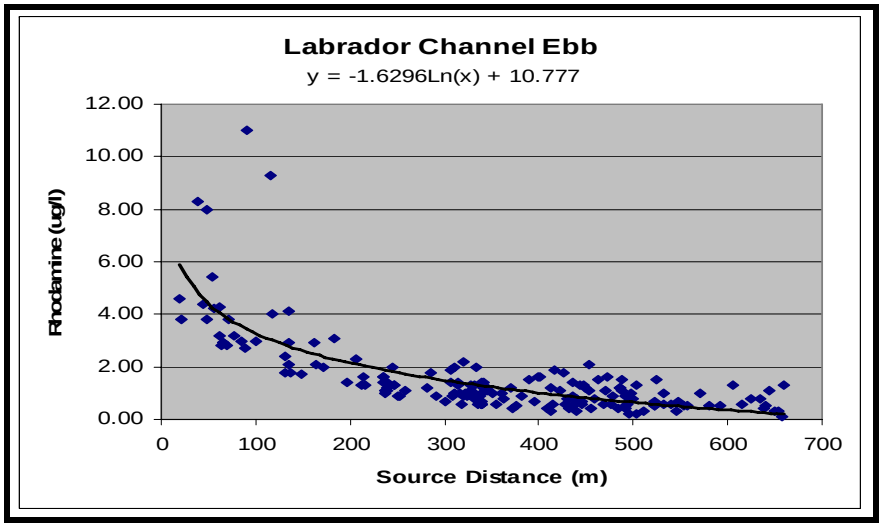
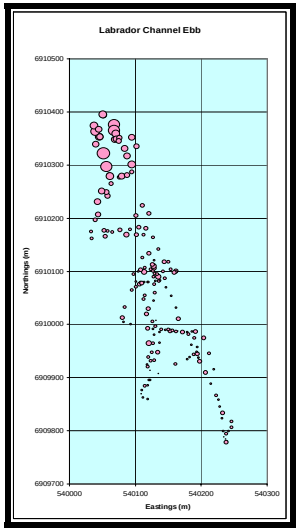


Figure 16 Labrador Channel Ebb Tide





Rhodamine Levels and Distance from Source

Drogue Tracks and Location

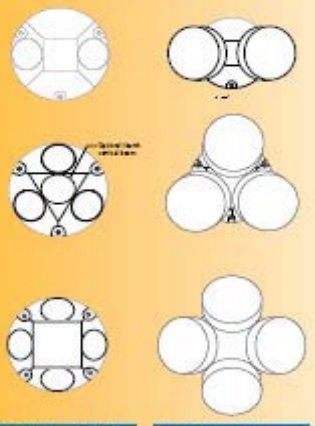
Rhodamine Levels and Locations

APPENDIX A SONTEK 1.5 MHZ ADCP SPECIFICATION

PERFORMANCE SPECIFICATIONS

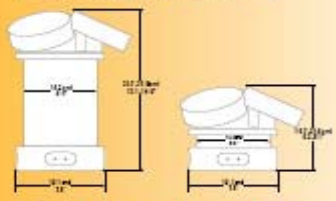
SonTek ADP™ Acoustic Doppler Profiler

Transducer Configurations



1000 kHz and Higher | 500 kHz and Lower

Housing Configurations



Standard | Low-Profile

*Actual dimensions are dependent upon system frequency and transducer configuration.

SonTek
The World Leader for Water Velocity Measurement

SONTEK ADP SPECIFICATIONS

Available Frequencies and Ranges

Frequency (kHz)	3000	1500	1000	500	250
Maximum Profiling Range (m)	3-6	15-25	25-40	70-120	120-180

Velocity Data
- Range: ±10 m/s
- Resolution: 0.1 cm/s
- Accuracy: ±1% of measured velocity, ±0.5 cm/s
- Up to 100 range cells

Standard features
- Robust, digital signal processing
- 8 bit A/D conversion
- Three-beam transducer for 3D current measurement
- Transducer shading for minimal sidelobes
- Oversize piezoelectric ceramic for narrow beams
- Recessed wet-matebale connector
- Temperature sensor

Hardware options
- Two-beam side-looking configuration for horizontal profiling
- Four-beam Janus configuration
- Four beam configuration with one beam oriented vertically
- Low-profile housing (DSP electronics located in a separate splash-proof box)
- Full ocean depth rating
- Internal recorder (20, 40, 85, 170 or 340 MB)
- Internal compass/two axis tilt sensor
- External battery case
- Self-contained configuration with batteries and electronics in a single housing
- Strain gage pressure sensor (0.1% accurate)
- Internal RPT pressure sensor (0.01% accurate)

Performance options
- Bottom tracking/DGPS interface for use from a moving boat
- SonWave wave spectrum package
- Pulse-coherent mode for high resolution profiling (contact SonTek for details)

Windows 95/98/NT Software options
- RiverSurveyor package for real-time river discharge measurements from moving boats
- CurrentSurveyor for velocity profiling from a moving vessel
- CurrentMonitor for fixed installations
- ViewADP for post-processing

External sensor options
- SeaBird MicroCat CT
- D&A OBS turbidity
- Paroscientific quartz pressure sensor
- Other sensor interfaces are available, please contact SonTek

Power Consumption (Typical Continuous Operation)
- 12-24 VDC
- 2.0-2.5 W Operating mode
- Less than 1 mW Sleeping mode
- Total battery capacity (3 packs at 5° C): Alkaline 1800 Wh

Compass/Tilt Sensor
- Resolution: Heading, Pitch, Roll 0.1°
- Accuracy: Heading ±2°
- Accuracy: Pitch, Roll ±1°

SonTek's customer support is unsurpassed in the industry. Our experienced and professional staff is ready to assist you with the use and application of the ADP.

CORPORATE HEADQUARTERS

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website: www.sontek.com

MADE IN U.S.A.

APPENDIX B SAN JOSE DGPS RECEIVER

SAN JOSE NAVIGATION, INC.
Professional in Navigation & Communication

DGPS Receiver

DGPS-220-PC

(USCG/IALA Beacon compatible)

Chapter 6 Technical Information

6.1 Specifications:

6.1.1 GPS RECEIVER GENERAL

SIGNAL PROCESSING	
Antenna:	High-reliability ceramic patch
Antenna LNA gain:	26+/-2dBi, NF: 2.0dB max
Receiver Frequency:	1575.42MHz, C/A code, L1 band
Receiver Architecture:	12-channel all-in-view algorithm tracks & uses up to 12 satellites
Update Rate:	1 second continuous
Dynamics:	Up to 49m/s.s (tracking sustained)
Datum:	WGS-84 plus 170 user selectable datum
ACCURACY	
GPS Positioning Accuracy:	15m (2DRMS, L1, C/A code, HDOP<=4 without SA)
GPS Positioning Speed:	0.1 Kt RMS
DGPS Positioning Accuracy:	1~5m (2DRMS, L1, C/A code, HDOP<=4)
DGPS Positioning Speed:	0.1 Kt RMS
TIME TO FIRST FIX	
Cold Start:	90 seconds
Warm Start:	20 seconds
Reacquisition:	2 seconds

6.1.2 BEACON RECEIVER GENERAL

SIGNAL PROCESSING	
Frequency Range:	283.5~325.0 kHz
Channel Spacing:	500 Hz
Frequency Resolution:	0.01 Hz
Minimum Signal Strength:	< 5 uV/m @100bps
Dynamic Range:	> 90 dB
Adjacent Channel Rejection:	60 dB @1 kHz
Acquisition Time:	< 2 sec., manual command
	< 2 sec., automatic warm start
	< 1 min., automatic cold start
Selection of Station:	Automatic or manual
Signal Detection:	Direct digital synthesis (DDS)
DATA PROCESSING	

APPENDIX C YSI 6600 RHODAMINE SONDE

YSI Environmental

YSI 6600 Sonde

Featuring 75-day battery life — the longest in the industry — the YSI 6600 has a second optical port to enable simultaneous use of self-cleaning chlorophyll or rhodamine and turbidity. It will simultaneously log at programmable intervals the entire suite of YSI parameters and store 150,000 individual parameter readings.

- 75-day battery life
- Deep depth to 656 feet
- Two optical ports for self-cleaning turbidity and chlorophyll or rhodamine probes
- Open-channel flow

Long Deployment

An important advantage of the YSI 6600 is the capability for long-term monitoring and profiling. In addition to long battery life, the YSI 6600 measures dissolved oxygen with YSI's exclusive Rapid Pulse™ stirring-independent sensor. Chlorophyll, rhodamine, and turbidity are measured with self-cleaning sensors that are not affected by variations in ambient light.

The oxygen sensor measures up to 50 mg/L, broad enough for super-saturated water. YSI's chlorophyll sensor provides a convenient, *in situ* monitoring system for detecting chlorophyll content in phytoplankton, which can be used to predict algae blooms and nutrient loading in water. The rhodamine sensor allows for time-of-travel and mixing/dispersion zone studies while logging water quality parameters.

Pure Data for a Healthy Planet.™

Easy-to-Use Data Analysis

Included with the YSI 6600 is EcoWatch® for Windows® software, providing user-friendly data analysis and statistics. This exclusive YSI tool is in English and French, as is the instrument's software.

Instrument Specifications

Medium	Fresh, sea, or polluted water
Temperature	-5 to +45°C
Computer interface	RS-232, SDI-12
Logging memory	384K; logs at programmable intervals and stores 150,000 readings
Software	EcoWatch for Windows included: PC-compatible, 3.5" disk drive; 386 processor or better running Windows 3.1 or later; 4 MB RAM minimum; English and French.
Size	3.5" OD x 20.4" length (8.9 x 52 cm)
Weight with batteries :	6 lbs (2.7 kg)
Internal power supply	8 C alkaline cells
Battery life	75 days at 15-minute sampling intervals at 25°C
External power supply	12 VDC

Rhodamine	Range	0 to 200 µg/L; 0 to 100% FS
	Resolution	0.1 µg/L; 0.1% FS
	Accuracy	±1.0 µg/L; 5% of reading
	Depth	200 feet (60.96 m)

www.YSI.com

APPENDIX D DAILY PROCEDURES EXAMPLE

Tuesday

08:00 hrs	Print out weather and tides for the day Get the gear ready for loading
09:00 hrs	Volunteers to meet at G5 room 2.44 Load up Toyota
09:30 hrs	Arrive boat shed, pick up Triton Take Triton to Spit Marine Stadium slipway
10:00 hrs.	Launch Triton Team 1 mobilise Triton
11:00 hrs	Team 2 return Triton trailer and pick up Scylla Launch and mobilise Scylla Check all equipment working and functional.
12:00 hrs	Head out to survey area
12:30 hrs	Set up ADCP on Triton Check radios Set up YSI on Scylla Set up and check GPS units on Scylla Set up 3 point anchoring system on Triton. Refuel pump Load dye into discharge system
12:55 hrs	Start firefighter pump.
13:00 hrs	Start dye release
14:00 hrs	Finish dye release
14:05 hrs	Relocate to next site
14:15 hrs	Start 2nd dye release
15:15 hrs	Finish second dye release
15:30 hrs	Back to boat ramp Stack equipment away in boats Take Scylla back to boat shed Rinse Scylla engine and boat Return with Triton trailer Take Triton back to boat shed Rinse engine and boat
18:00 hrs	Back to uni. Unpack the ute

APPENDIX E TRITON FIELD SHEET AND METHODOLOGY EXAMPLE

TRITON	DATE	COMMENTS
12:55 hrs	Start pump	
13:00 hrs	Open tap for dye. Note time Take dye sample Throw marker drogue over side Note current velocity and direction Maintain dye level between 150 and 250 ml mark.	
13:12 hrs	Note time Take dye sample Throw drogue over side Note current velocity and time Maintain dye level between 150 and 250 ml mark.	
13:24 hrs	Note time Take dye sample Throw drogue over side Note current velocity and time Maintain dye level between 150 and 250 ml mark.	
13:36 hrs	Note time Take dye sample Throw drogue over side Note current velocity and time Maintain dye level between 150 and 250 ml mark.	
13:48 hrs	Note time Take dye sample Throw drogue over side Note current velocity and time Maintain dye level between 150 and 250 ml mark.	
14:00 hrs	Note time Take dye sample Throw drogue over side Note current velocity and time Switch off dye tap Rinse and wash dye mixer box area Switch off pump once clear water in box. Note time.	

COMMENTS AND NOTES

APPENDIX F SCYLLA FIELD SHEET AND METHODOLOGY EXAMPLE

Scylla Methodology **Date**

13:00 hrs Once pump starts to discharge, note time and check values on YSI
Follow first drogue and when 10 m from Triton, commence a cross section.

Sample Sample Sample

Repeat until second drogue dropped in.

Sample Sample Sample

13:12 hrs Second drogue dropped in. Head up from drogue 1 to drogue 2 taking readings as you go. Once at drogue two, head to clear water and repeat cross section method.

Sample Sample Sample

Head down to drogue 1 and repeat cross section method.

Sample Sample Sample

Back to drogue 2. Keep repeating until third drogue dropped in

Sample Sample Sample

Repeat for drogues 3
Sample Sample Sample

Repeat for drogues 4
Sample Sample Sample

Repeat for drogues 5,
Sample Sample Sample

Repeat for drogues 6,
Sample Sample Sample

APPENDIX G STANDARD SOLUTION PREPARATION

Preparation of Standards for Dye Studies
using Rhodamine WT

What is a Standard?
A standard is a known concentration of the dye you are injecting. It is used to calibrate the Turner Designs Model 10 Fluorometer to the desired sensitivity. The fluorometer reading of the standard will be compared with the readings of unknown samples to obtain their concentrations. A known concentration is made by weighing or measuring a sample of tracer and precisely diluting it.

In many cases, the standard will be a known dilution of dye, not a known concentration. For example, in flow rate measurements you are only interested in how much a stream dilutes the dye, not what the actual concentration is. Thus, you do not need to know the concentration of the dye (in parts per billion or other units) when you calibrate your fluorometer. You need only know the dilution factor for the standard and the fluorometer reading, which you will then compare with the fluorometer readings for your unknown samples collected after dye has been injected into the stream. This will allow you to calculate the extent to which the stream dilutes the dye.

Note: For more information on dye studies and whether a known concentration or dilution is required, see the monographs "A Practical Guide to Flow Measurement" and "Flow Measurements in Sanitary Sewers by Dye Dilution", available from Turner Designs.

Units of Measurement
Use whatever units suit your purpose best. The EPA guidelines on allowable levels will typically be in micrograms per litre (1). Other studies are described in milligrams per cubic meter (mg/m3) or parts per billion (ppb). The simplest to use when making dilutions is grams per gram, which, for all practical purposes, is the same as grams per millilitre.

The easiest way to record and to think of these units is in exponential notation. If you are not used to this, and are not comfortable with it, move your decimal point around. It is very easy, however, to think in exponential terms:

1.3 grams dissolved in 100 ml, makes a 0.013 g/g solution. In exponential notation this is 1.3 x 10-2. If 1 ml is diluted to 100 ml (100 ml is 102 ml), then the new concentration is 1.3 x 10-4.
Some conversion factors:

1 gram/litre = 1 part per thousand (ppt) 10-3
1 millilitre/litre = 1 part per thousand (ppt) 10-3
1 milligram/litre = 1 part per million (ppm) 10-6
1 microgram/litre = 1 part per billion (ppb) 10-9
1 milligram/cubic meter = 1 part per billion (ppb) 10-9

Linearity
Note: Rhodamine WT comes as a 20% solution in water (meaning it is 20% active ingredient). The EPA guidelines are in terms of active ingredient. Thus, one microgram of the 20% solution in one litre is 0.2 ppb active ingredient (or 20% of 1 ppb).

Instrument readings for fluorescent dyes are proportional to concentration (linear) from the lowest detectable level up to a certain concentration. Above this concentration, a multipoint calibration curve may be used to obtain concentrations. Then, at a certain concentration

(somewhere at about five to ten times the upper limit for the linear range) the curve flattens out and eventually takes a nose-dive. This critical concentration is a function of the compound and of the path length of the flow cell or cuvette.

For practical purposes (using the Turner Designs Model 10 Fluorometer equipped with the 25-mm flow cell or cuvette holder), Rhodamine WT is linear to 0.5 ppm (500 ppb, 5 x 10-7, or 500 micrograms/litre). In terms of active ingredient (the 20% solution of Rhodamine WT), it is linear to 0.1 ppm (or 100 ppb, 1 x 10-7, or 100 micrograms/litre).

Active Ingredient or 20% Solution?
Since Rhodamine WT comes as a 20% solution, a decision should be made at the outset about whether to make the standard as 100% tracer or in terms of active ingredient. The first impulse is to do all calculations on the basis of the active ingredient. However, even to meet the EPA guidelines, you need only keep in mind that 20% of the original solution is active ingredient. For other purposes, it is immaterial whether you take the 20% into account. If you discharge 20 pounds of Rhodamine WT.

solution, or inject a 10-fold dilution, it doesn't matter that the original material was only 20% pure. If you consider the Rhodamine WT solution to be pure tracer, then all dilutions are relative. For example, if you have made a 100 parts per billion dilution based on 100% tracer, your final dilution will be 20 parts per billion active ingredient. Whatever method you choose, be sure to clearly mark your dilutions as to 100% tracer or active ingredient.

Measuring by Weight or Volume
For flow measurements and other studies where dye is to be added to a body of water, if you plan to add dye in pounds, grams, or other weight measure, then your standard must be made by weighing. If you are adding by volume, then the standard must be made by volume measurements. The important thing is to make your standard the same way you make the dye concentration to be injected.

Note, however, that most of the literature cites the specific gravity of Rhodamine WT as 1.2 (sometimes 1.19). Recent literature accompanying the dye says 1.15. Thus, one gram equals 1/(sp.gr.) millilitre. If you add by volume, you could be adding as much as 20% more dye than if you add by weight. Therefore, if you are concerned with absolute concentrations (as with an EPA study), you should make an initial 100-fold dilution by weight (or compensate for the specific gravity). A 100-fold dilution by weight has a specific gravity of 1.002. For the vast majority of studies, errors of 0.2% in doing further dilutions, whether by weight or volume, are acceptable.

If you weigh, it is best to weigh directly into a volumetric flask. (See discussion of flasks below.) This avoids the problem of having to rinse whatever vessel is used for weighing. All of the material must wind up in the flask. Since it will be diluted with water, the rinsing can be done with water.

If you measure by volume, an accurate method is to use a large-tip pipette of at least 10-ml capacity and measure dye into a 1-liter volumetric flask (a 100-fold dilution). Even more accurate is to measure dye with a 20-ml pipette and dilute to 2 litres. The larger the pipette, the smaller the surface area with respect to the volume, hence the smaller the error due to incomplete drainage. The error from a 10-ml pipette will probably be negligible for most work. It certainly should be less than 1%.

The most accurate way to measure the tracer by volume is to fill a 10-ml volumetric flask to the mark, then rinse the tracer into a 1-liter volumetric flask. You can't rinse a pipette, as it is made to deliver the stated volume. Volumetric flasks contain the stated volume, so if you want the stated volume out of the flask, you must rinse.

Note, however, that there is not much point in preparing your standards to an accuracy greater than the means by which the tracer will be added to the system.

The Volumetric Flask
Put your measured sample into the flask, then add water up to the line. The correct level is when the bottom of the meniscus touches the calibration line. The more precise Class A flasks will be accurate to 0.03% for a 1-liter flask, and to 0.16% for a 100-ml one. Less accurate flasks have a tolerance of twice this.

After adding the dye, mix thoroughly. The proper way is to invert the flask (hold the cap on!). When the air bubble has risen, swirl it for a few seconds. Right it; let the bubble rise; then invert and swirl again. Do this ten times.

To care for a volumetric flask, rinse it thoroughly with distilled water. Occasionally, wash it with a mild detergent. To make sure it is clean, put a few millilitres of water in it, swirl, and pour into a cuvette. Then, compare the fluorometer reading with clean water. Rinse until they read the same. The flask does not have to be dry to use it.

The Pipette
There are three choices: a pipettor, a measuring pipette, or a volumetric pipette.

Pipettor. Advantageous for most users. It is not necessary to learn to control the leakage while you adjust to a line, and disposable plastic tips are used. Accuracy is generally about 1%. There are many brands on the market. They can be purchased in fixed volumes, for example, 100 microliters (0.1 ml), 1 ml; or adjustable volumes, 10-100 microliters, 0.1-1 ml.

Pipettors are relatively inexpensive and easy to use: 1) Push a button until you feel a stop; 2) Insert tip in solution; 3) Release slowly to draw up the set volume; 4) Push past first stop to a second one to eject and blow out the last drop. Some pipettors have a further position that ejects the tip.

Measuring Pipette. Available in disposable form. The accuracy of the disposable ones, +/- 2%, is no worse than the nondisposable, and a clean one is always available. When using, let it drain, then blow the last portion out.

Volumetric Pipette. Like the volumetric flask, this is very accurate. First, fill the volumetric flask about 1/2 full with water. Then, fill the pipette to the line, and, holding the pipette vertical, allow it to drain. When it stops dripping, hold it for about 10 seconds longer, then touch the drop on the end to the surface of the water (just once, and only briefly). Remove the pipette.

Problems: A pipette must be dry when you use it, or it must be rinsed with the material you intend to pipette. Volumetric pipettes are difficult to clean and rinse. If you need the accuracy, buy quantities of them, so you can use them, then clean them at leisure (preferably with access to a laboratory pipette washer).

Making Standard Dilutions
For a standard, you need any concentration no greater than the linear range of your tracer (for the rhodamine dyes, approximately 100-ppb (0.1-ppm; 100-micrograms/liter) active ingredient.
To obtain this concentration, you will make serial dilutions. By this, we mean you take your concentrated solution and make a dilution of it. You mix it thoroughly, then make a dilution of that, and so on, until the desired concentration is obtained.

We recommend preparing a higher concentration, i.e., around 0.1-ppm (100-ppb or 10-7) active ingredient. At these high levels (high for fluorescence), contamination will be less of a problem. Contamination from dirt or other things is not a problem, but spurious tracer could be. In

preparing the standards, you are handling the pure material and high concentrations, and it is safer to use the highest standard that is convenient.

Note that the dilutions you are after can be achieved in a variety of ways. The easiest way is with 1- and 10-ml pipettors, and a choice of 100-ml and 1-liter flasks. If intermediate concentrations are desired, use an adjustable pipettor, or pipette several shots into one flask, or use intermediate-size flasks (they are available in 200-, 250-, and 500-ml sizes). Generally, all you are after is some concentration not greater than 500 ppb (0.5 ppm)--or 100 ppb (0.1 ppm) if dealing in active ingredient. Since readings are proportional to concentration at or below this point, it is simply a question of convenience.

Don't use **all** clean water. Your last dilution should always be done twice, once in distilled water, and once in the water in which the measurement will be made. This is because sometimes there are substances in the test water that interfere with the reading. This doesn't happen often, but it can invalidate your readings if you don't recognize it.

Your standard will be the dilution in the system water, but first you need to see that it reads the same as the dilution in distilled water -- or make sure you understand any difference.

To prepare a 100-ppb (active ingredient) standard of rhodamine WT (20% solution):
First, prepare a 100-fold dilution by weight. (See section MEASURING BY WEIGHT OR VOLUME for an explanation.) Using an accurate laboratory scale, weigh 1 gram of dye directly into a 100-ml volumetric flask. The dye may be dripped into the flask with a pipette until 1 gram is obtained. Then dilute to the mark with distilled water. You now have a 10-g/liter (10 ppt, 10-2) concentration of your tracer.

Note 1: You could obtain the same concentration by weighing 10 g into a 1-liter flask, or 20 g into a 2-liter flask.

Note 2: If you intend to inject dye by volume, then pipette 1 ml of dye into a 100-ml volumetric flask and dilute to the mark with distilled water. Or measure 10 ml of dye into a 10-ml volumetric flask and rinse into a 1-liter flask. Then, dilute to the mark with distilled water. This will yield a 10-ml/liter (10-ppt, 10-2) dilution. (Keep in mind the specific gravity factor. See MEASURING BY WEIGHT OR VOLUME, above.)

Next, pipette 1 ml (or weigh 1 gram) of the dilution in #1 (10-2 or 10 ppt) into a clean 100-ml volumetric flask and dilute to the mark with distilled water. Mix thoroughly. You now have a 10-4, or 100-ppm, dilution.

Now, pipette 5 ml (or weigh 5 grams) of the dilution in #2 (10-4 or 100 ppm) into a clean 1-liter volumetric flask and fill to the mark with system water. Mix thoroughly. You now have a 10-7 (or 100-ppb; 0.1-ppm) active ingredient standard.

Note: We measured 5 ml because rhodamine WT comes as a 20% solution (meaning 20% active ingredient). If you are not concerned with active ingredient, then diluting 1 ml 1000-fold yields a 100-ppb dilution of tracer (or 20-ppb active ingredient).
Repeat step 3, using distilled water. Compare fluorometer readings of this dilution with that of #3.

To prepare a 100-ppb standard of rhodamine B or other dye in powder form:
First, prepare a 100-fold dilution by weight. (See MEASURING BY WEIGHT OR VOLUME above, for an explanation.) Using an accurate laboratory scale, weigh 1 gram of dye directly into a 100-ml volumetric flask. Then dilute to the mark with distilled water. (Be sure to mix thoroughly; the powders can be difficult to mix.) You now have a 10-g/liter (10-ppt, 10-2) concentration of your tracer.

Note: You could obtain the same concentration by weighing 10 g into a 1-liter flask, or 20 g into a 2-liter flask.

Next, pipette 1 ml (or weigh 1 gram) of the dilution in #1 (10-2 or 10 ppt) into a clean 100-ml volumetric flask and dilute to the mark with distilled water. Mix thoroughly. You now have a 10-4, or 100-ppm, dilution.

Now, pipette 1 ml (or weigh 1 gram) of the dilution in #2 (10-4 or 100 ppm) into a clean 1-liter volumetric flask and fill to the mark with system water. Mix thoroughly. You now have a 10-7 (or 100-ppb; 0.1-ppm) standard.

Note: Rhodamine B is also available in 30% or 40% active ingredient solutions. If you are working with one of these dilutions, then what you actually have is a 30-ppb (30%) or 40-ppb (40%) standard, based on active ingredient.

Repeat step 3, using distilled water. Compare fluorometer readings of this dilution with that of #3.

Thus, the necessary concentration for your standard can be achieved in a variety of ways. For example, a 5 x 10-7 or 500-ppb dilution could be achieved in the following cases:
You are doing a flow measurement, and have a dye concentration of 5 x 10-3 (5 ppt). To achieve a 5 x 10-7 (500-ppb) dilution, make two 100-fold dilutions of the 5 ppt.

You have a 5% solution (5 x 10-2) of dye; make one 1000-fold dilution and one 100-fold dilution; or a 10-fold, followed by two 100-fold dilutions.

Making more than one Concentration
Whether or not you make more than one concentration depends on such considerations as the confidence you have in your dilution, and how important it is that your standard be exactly right. If this is your first time, it would be important to prepare a range of concentrations and plot a standard curve. This will test your proficiency and make you more confident. The readings, however, should be linear with concentration. You really need only one concentration (and a blank).

The most important thing to do is to be sure there were no errors, i.e., a lapse in counting measurements, an accidental contamination, an air bubble in the pipetted sample, etc.
It is not so much, therefore, the need for more than one concentration as it is a need to duplicate your preparation. This means from the beginning. If you choose to make several concentrations at the final dilution, fine.

pH, Turbidity, and Chlorine
pH. When you are taking measurements, the most serious, nonvisible problem in test waters is pH. Any pH between 4.5 and 10.5 is fine. Most systems should fall in this range, but if the pH does not, the fluorescence will drop off rapidly. It is, however, reversible. If the dilution in the system water reads very low and there is no obvious reason (intense colour, very high turbidity, etc.), **check the pH**. If you can't check the pH, get some vinegar and some baking soda. Try adding a pinch of the soda to one test tube, and a drop or two of vinegar to another. Neither is capable of taking the pH too far in the other direction. If this causes the reading to increase, add a bit more to see if you have enough, then plan on adding the same amount to all your samples. If pH is not the problem, then the study probably cannot be done with a fluorescent tracer. This is extremely rare, and it is likely that someone is dumping a high concentration of a very strong oxidizing agent. Investigate.

Turbidity and Colour. These are covered in the monograph "A Practical Guide to Flow Measurement." Generally, it takes considerable turbidity or colour to interfere with the readings.

The interference is a percentage reduction in reading. For example, say 100 ppb reads 900 in clean water. A 10-ppb solution would read 90.0, and a 1-ppb solution, 9.00. Your 100-ppb solution in the system water reads 810 (a 10% reduction). The 10-ppb solution will read 81.0 and the 1-ppb solution, 8.10. In other words, if you use the dilution in the system water as the standard, there will be no error, and no correction needs to be made.

Should you calibrate this way if there is a 90% loss of reading? Theoretically you could, if you were absolutely positive that the turbidity or colour would be constant during the study. In practice, it would be much better to increase the dye concentration by a factor of 10, then dilute all samples, the blank, and the standard 10-fold with clean water.

pH and Chlorine. In potable water, we found in lab tests that chlorine appears to destroy rhodamine WT within a few minutes at all pH levels, even with very low levels of chlorine (.1 part per million). There is at least one very thorough published study that showed little effect of chlorine on rhodamine WT in wastewater (2). We speculate that the suspended solids in wastewater have a prophylactic effect.

Storing Samples and Standards

The tracers will not degrade, and if stored in the dark, are stable for years. After you have completed your study, you may find that something doesn't fit. If you have a sample of the tracer you injected, samples of your dilutions, and your field samples, you can always re-read your dilutions and see what happened. Since the Model 10 Fluorometer 10-030 Cuvette System requires only 4 ml of sample, there is no need to store large amounts. Scintillation vials (discussed in "Flow Measurements in Sanitary Sewers") hold about 20 ml, and 500 of them require very little storage space.

APPENDIX H RISK MANAGEMENT PROTOCOL

RISK MANAGEMENT PROTOCOL

To minimise risks during the operation of the dye release experiment, a number of procedures and protocols have been incorporated into the operation.

Risk	***Procedure***
Environmental pollution	Rhodamine WC has been specifically developed for use as a dye tracer for potable water systems plus the proposed system requires concentrations lower than previous studies.
Notifying third parties	The local Harbour Master, EPA, NRW and Qld Transport will be notified prior to the commencement of the operation
Public concern at bright staining in the water	Rather than undertaking a traditional high concentration single release patch study a continuous release plume system has been developed.
Accidental spillage of dye concentrate	Dye will be pre-mixed onshore prior to being brought onboard the vessel. At all times it will be in sealed 20 litre containers.
Unforseen events in the surrounding area	Should the experiment have to be stopped suddenly, a shut-off valve has been incorporated in the dye release piping, which will stop the dye release immediately.
High dye concentrations released.	Visual observations and 10 minute sampling will ensure that the released dye concentrations do not exceed the specified levels.
Adverse waves and passing boats	The dye concentrate will be contained in a sealed container and all transport of the dye to the mixing chamber will be via secure leak-free piping.
Saturation of the surrounding area with dye	Each experiment will last no longer than one hour after which the dye stream will be switched off and clean seawater pumped through the system. Subsequent experiments will not be started until the surrounding area has returned to clean seawater conditions.
Staining of other vessels	Studies have shown that Rhodamine WC does not stain vessels at the concentrations used in this study.
Safety Equipment	Gloves, safety goggles, mop up rags and a standby fire bucket filled with clean seawater will be available for immediate use should they be needed.

APPENDIX I MEDIA COVERAGE

MEDIA MONITORS
INCISIVE INSIGHT

Gold Coast Bulletin
14/06/2007
Page: 23
General News
Region: Gold Coast QLD Circulation: 42263
Type: Regional
Size: 121.04 sq.cms
MTWTF--

Boffins to see red in waterway

by Andrew MacDonald

A HARMLESS red dye will be released into the Broadwater during June and July as part of an examination of water movement in the popular waterway.

Researchers from the Gold Coast City Council and the Griffith Centre for Coastal Management will release about 50g of Rhodamine WT dye on 24 occasions between June 18 to 23 and July 10 to 24.

The study is being undertaken as part of the development of a computer model designed to simulate conditions in and around the Broadwater.

While calls for a solution to the build-up of sand in the Broadwater have grown louder in recent months, Griffith Centre for Coastal Management director Professor Rodger Tomlinson said sediment movement was one of many issues the model would examine.

"The intention of the model is to look at a range of conditions that could affect the Broadwater," he said.

Prof Tomlinson said the completion of the dye tests would mark the end of the second of three stages of the model development.

The completed model would help in assessing the long-term health of the Broadwater as the Gold Coast boomed.

"Another thing we will be able to look at is appropriate sewage disposal as the Gold Coast's population continues to grow," he said.

Release of the dye was necessary to accurately complete the model.

"This phase is to simulate how the water disperses and moves through the Broadwater," he said.

"It's a miniscule amount because we have very precise instruments," he said

MEDIA MONITORS
INCISIVE INSIGHT

Gold Coast Sun
20/06/2007
Page: 15
Regional Changes - Central
Region: Gold Coast QLD Circulation: 143011
Type: Regional
Size: 108.22 sq.cms
--W----

Boaties see red

IT'S not the Red Sea or a biblical plague but the Broadwater will turn red in the next few weeks for scientific studies.

Gold Coast City Council, the Griffith Centre for Coastal Management and international experts will release special dye, the colour of pink cordial, to determine the water flow and gauge the health of the Broadwater and estuarine waters.

Water Sustainability Committee chairwoman Daphne McDonald said the tests would give a better understanding of how the water dispersed in spillages from boats, contaminants in tributary streams, sediment and recycled water release.

"These studies are exciting and will provide invaluable information," she said.

"Local experts, including Professor Roger Tomlinson from Griffith Centre for Coastal Management, with our staff, will use special red dye (Rhodamine WT) for the field exercise."

By LEAH HALLETT

Up to 24 tests will be run between the Coomera River and Main Beach until July 24 with the dye released from the back of a research houseboat through a submerged pipe.

The dye will dissipate quickly and the project team will track its direction and dispersion using highly-advanced technical equipment.

Dye release testing is a common technique used by Australian and international engineering and scientific research.

The dye is harmless to the environment, people and marine life and the Queensland Environmental Protection Agency will be notified of the location and timing of the dye releases.

The council said the use of the Broadwater would not be affected but boat owners were encouraged to avoid the release area.

For details, call Gold Coast Water on 1300 366 692.

MEDIA MONITORS
INCISIVE INSIGHT

Albert & Logan News
27/06/2007
Page: 23
General News
Region: Beenleigh Circulation: 68503
Type: Suburban
Size: 233.61 sq.cms
--W-F--

No need to see red over water testing

A GREEN study this month will use red dye to help ensure the Broadwater and estuarine waters remain in the pink of condition.

Gold Coast City Council approved the study, running through June and July, to allow its staff, the Griffith Centre for Coastal Management and a team of international experts to collect information to guide the long-term health of the Broadwater and estuaries.

A total of 24 tests will be run between Coomera and Main Beach, with the second phase of the study taking place in July to capture the tidal range of the Broadwater.

A red dye, Rhodamine WT, which is harmless to the environment, people and marine life, will be used to monitor the movement of water. This will help provide a better understanding of how water is dispersed when there are spillages from boats, contaminants in tributary systems or recycled water is released.

During the study, the dye will be released from the back of a research boat through a pipe below the water line. The pink colour of the dye will be visible initially at the release point but will quickly dissipate.

Boating and fishing will not be affected by the tests but boaties are urged to avoid the release areas, to ensure the study returns accurate results.

For details of testing times, contact Gold Coast Water on 1300 366 692 or visit goldcoastwater.com.au/dyereleaseproject.

MEDIA MONITORS
INCISIVE INSIGHT

Gold Coast Sun
20/06/2007
Page: 22
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Red sea tests for waterway

IT'S not the Red Sea or a biblical plague but the Broadwater will turn red in the next few weeks for scientific studies.

Gold Coast City Council, the Griffith Centre for Coastal Management and international experts will release special dye, the colour of pink cordial, to determine the water flow and gauge the health of the Broadwater and estuarine waters.

Water Sustainability Committee chairwoman Daphne McDonald said the tests would give a better understanding of how the water dispersed in spillages from boats, contaminants in tributary streams, sediment and recycled water release.

Up to 24 tests will be run between the Coomera River and Main Beach until July 24 with the dye released from the back of a research houseboat through a submerged pipe.

The dye will dissipate quickly and the project team will track its direction and dispersion.

The dye is harmless to the environment, people and marine life and the Queensland Environmental Protection Agency will be notified of the location and timing of the dye releases.

A council spokesman said the use of the Broadwater would not be affected but boats were encouraged to avoid the release areas. For details call 1300 366 692.