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THE USE OF IALA WATERWAY RISK ASSESSMENT PROGRAMME (IWRAP MKII)

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1. INTRODUCTION

The IALA Waterway Risk Assessment Program (IWRAP Mk II) risk assessment process involves developing a model of the waterways to be analysed. The model describes the geometry of the relevant routes, the traffic volume and composition, as well as the bathymetry of the waterways in question.

Once the model has been defined, IWRAP Mk II calculates the average annual number of collisions and groundings likely to occur. This calculation is based on the above-mentioned model and a set of so-called Causation Factors which can be thought of as the probability that the vessel fails to make an evasive action to avoid the grounding or collision.

IWRAP Mk II only addresses the *frequency* of collisions and groundings, it does not consider the consequences associated with these incidents. It is left to the Analyst and the authority performing the analysis to assess the possible consequences of the incidents, however, the output of IWRAP Mk II tool is well suited for performing such an analysis after the calculations have been made.

1.1. OBJECTIVE OF THE IWRAP TOOL

The purpose of IWRAP Mk II is to provide Authorities with a standardised quantitative method to evaluate the probability of collisions and groundings in a given waterway. IWRAP Mk II allows different scenarios to be developed, so that changes in traffic volume or composition, changes in route geometry, changes in the mix of Aids to Navigation or the introduction of other mitigating options, may be evaluated in terms of changes in the average annual number (probability) of collisions and groundings.

1.2. BACKGROUND

IWRAP has evolved from a probabilistic methodology for estimating the probabilities of groundings and collisions, developed at the Technical University of Denmark, inspired by the work of Fujii and MacDuff in the 1970´s and the 'Minimum Safe Design' (MSD) tool originally developed in Canada and used by the Canadian Coast Guard.

When the first version of IWRAP was initially tested, the results obtained seemed credible and in accordance with the accident statistics in the considered area and experts were satisfied with the results. However, at a later stage, when the tool was applied to other areas it yielded an unrealistic high number of collisions and groundings.

In 2007 the IALA Risk Management Steering Group decided to initiate the development of a second generation of IWRAP. Thanks to the dedicated efforts of a team of IALA members, research institutes and universities, led by the Danish Maritime Safety Administration (DAMSA), a new tool, named IWRAP Mk II, was developed from scratch and validated.

The first training seminar dedicated to IWRAP Mk II was held in Kuala Lumpur, Malaysia in April 2009 using the Malacca Strait as a test case for training purposes.

IWRAP Mk II is a purely probabilistic approach, i.e. the MSD channel design criteria implemented in the first version of IWRAP are not included in IWRAP Mk II.

The basic IWRAP Mk II software is available free of charge to IALA members. A commercial version is also available which automates the inputting of information on volume and composition of the vessel traffic in a given area, based on AIS data.

2. IWRAP MK II RISK ASSESSEMENT METHODOLOGY OVERVIEW

IWRAP Mk II is implemented as a MS-Windows ™ based application that forms the framework for the process of defining a model of the waterway being analysed. The IWRAP Mk II Risk Assessment process involves the following steps:

- Defining Bathymetry, Routes, Waypoints and Legs;
- Entering Traffic Volume Distributions on each Leg;
- Defining Traffic Lateral Distribution;
- Grounding due to Drifting;
- Defining other traffic in the area;
- Selection Causation Probability Factors;
- Result calculation and assessment.

Usually, the Analyst would just assess the results in terms of annual number of collisions and groundings by setting up a baseline waterway scenario and comparing other scenarios to the baseline. If a cost-benefit analysis of different mitigating options is required, the Analyst would use the output of IWRAP Mk II to further assess the consequences of the resulting collisions and groundings.

2.1. DEFINING BATHYMETRY, ROUTES, WAYPOINTS AND LEGS

The first step of developing an IWRAP Mk II waterway model is to obtain as much information as possible on the geometry of the waterway, its bathymetry and its route layout. The bathymetry information can be obtained from Nautical Charts while information about the routes can best be obtained from AIS data, statistically processed to generate a so-called Density Plot. If such a plot is not available, route layout information may be obtained from other sources.

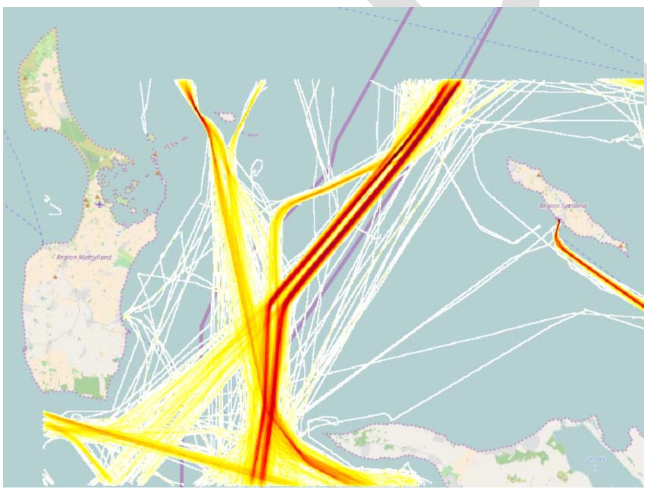

Figure 1 Waterway Density Diagram derived from AIS data

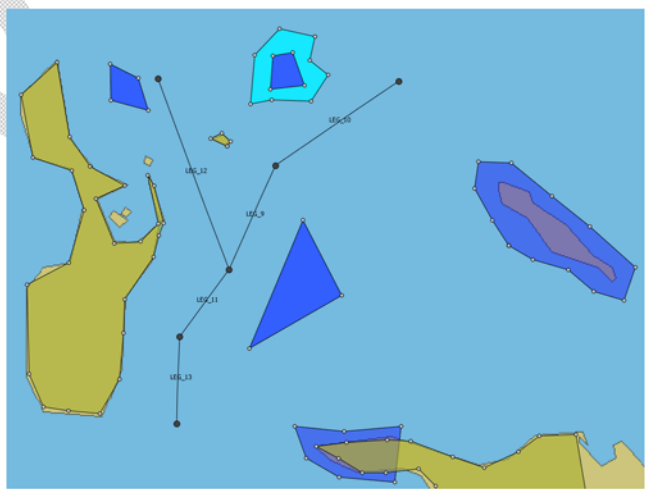

Figure 2 IWRAP Waterway model derived from AIS data and a Nautical Chart

This information is entered in the IWRAP Mk II programme using its Geographic Model Editor, resulting in a model similar to the one in Figure 2.

2.2. ENTERING TRAFFIC VOLUME DISTRIBUTIONS ON EACH LEG

Once the route layout has been defined, the Analyst needs to enter information about the traffic volume and the traffic composition in each direction on each route leg, using the Traffic Editor.

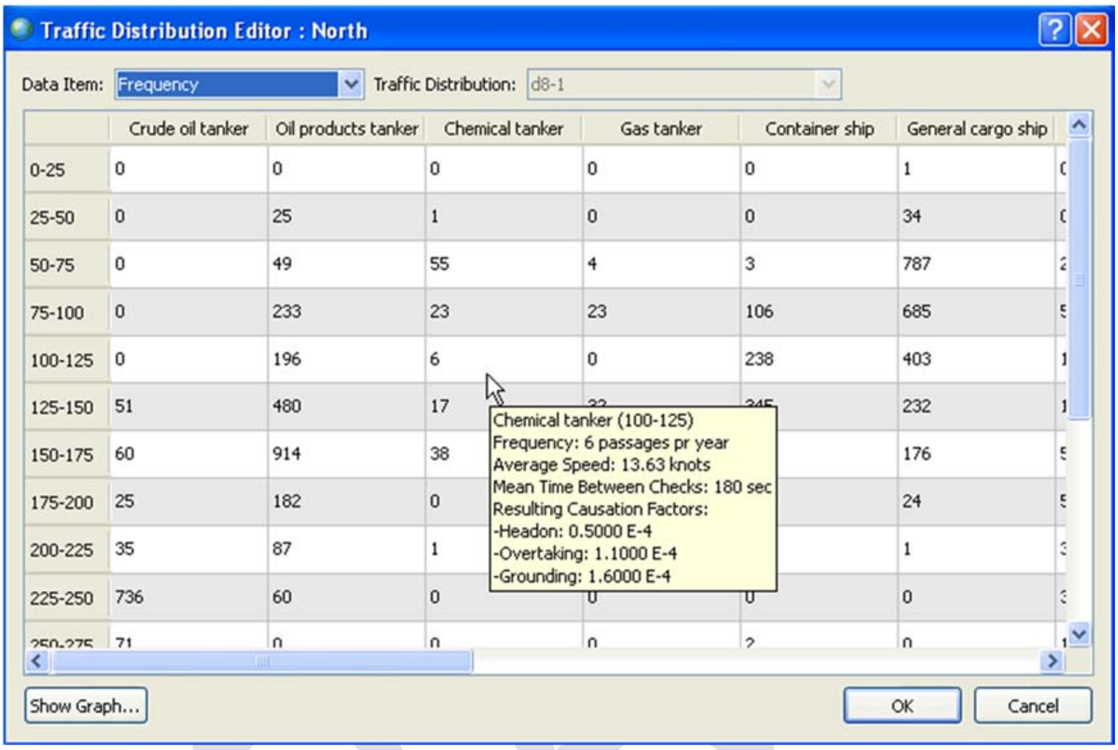

Figure 3 Traffic Volume Editor used for entering information about vessel traffic volume and composition

IWRAP Mk II uses 14 different types of vessel categories each of which is divided into several length categories. The information about the number of vessels in each category can be obtained from AIS data.

2.3. DEFINING TRAFFIC LATERAL DISTRIBUTION

Having defined the bathymetry, the route layout, waypoints and route legs, as well as the volume and composition/types of the vessels on each leg, the Analyst needs to define how the vessels are distributed laterally on each leg in each direction. This is done using the IWRAP Mk II leg editor.

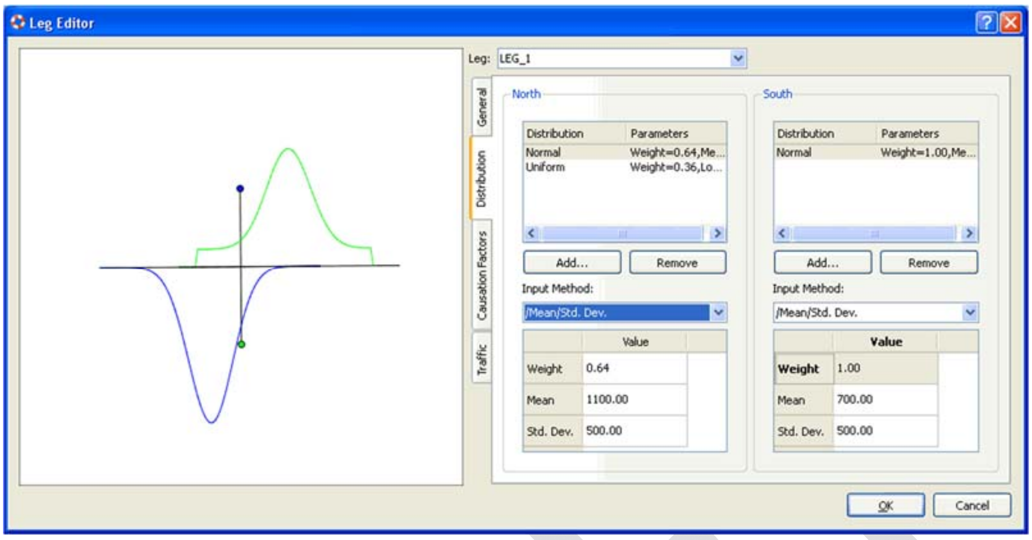

Figure 4 Route Leg editor used for entering information about lateral distribution of vessels on a route leg

Information about the lateral distribution of vessels can be obtained from AIS data. This is accomplished by defining a passage line perpendicular to the route leg and counting all vessels crossing the passage line while noting their lateral position on the passage line. The resulting lateral distribution can then be entered manually into IWRAP Mk II using one or more of the predefined standard distributions supported by IWRAP Mk II.

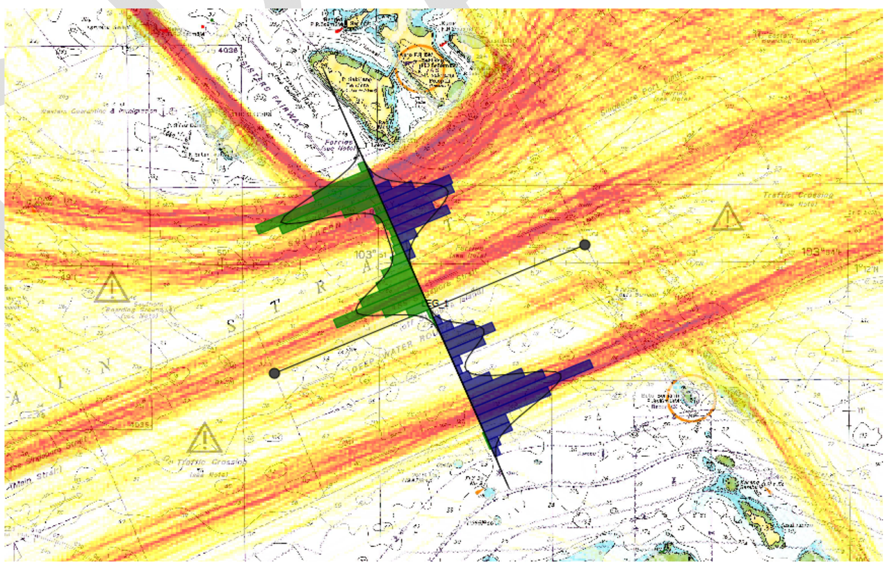

Figure 5 Lateral distribution of vessels on route legs

2.4. GROUNDING DUE TO DRIFTING

IWRAP Mk II is capable of modelling ships that run aground while drifting due to a power outage / blackout. The Blackout Frequency can be defined and the time taken to recover from the blackout (Repair Time) can be expressed in probabilistic terms (Figure 6). Also, the probability of drifting direction can be defined (Figure 7).

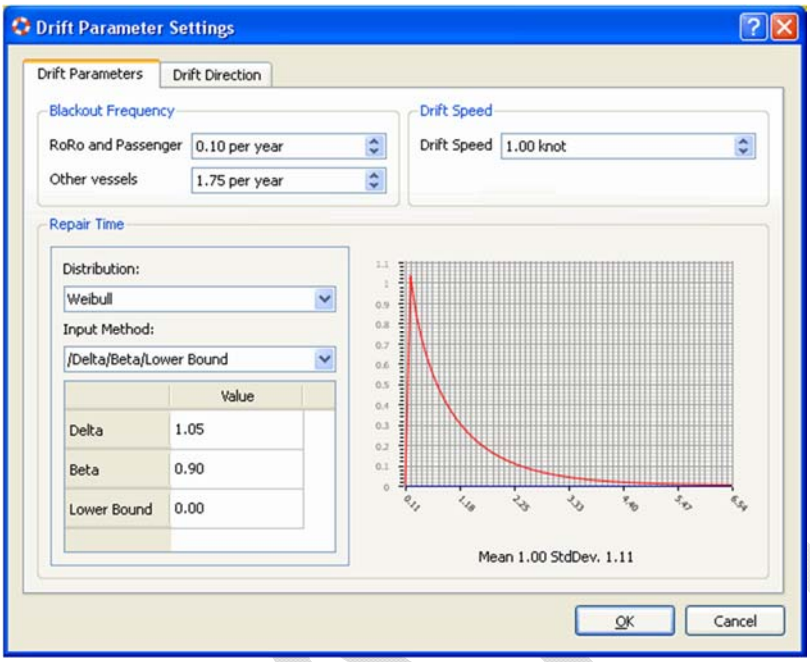

Figure 6 Example of a defined blackout frequency and the time it takes to recover from a blackout

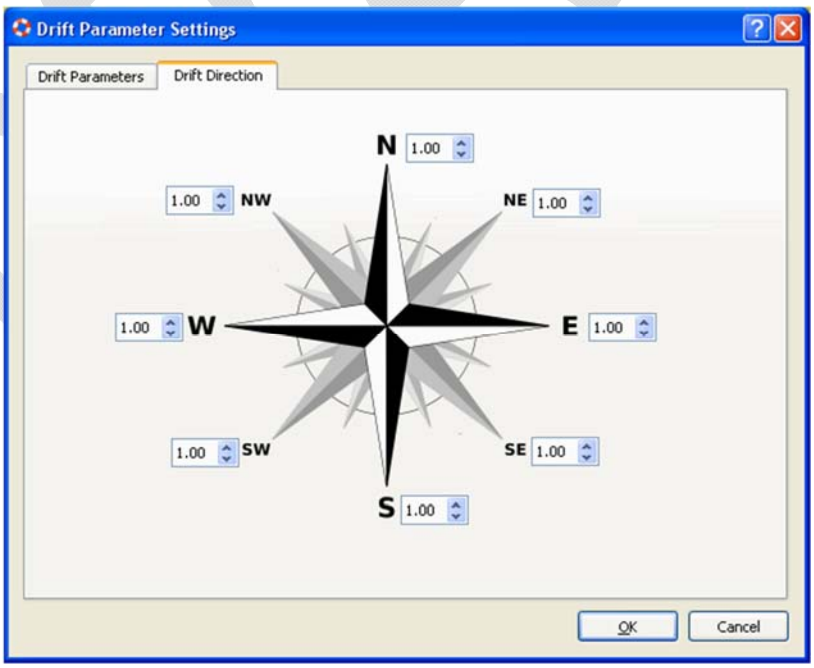

Figure 7 Example of the probability of drifting in a given direction during a blackout

2.5. DEFINING OTHER TRAFFIC IN THE AREA

Most of the information about traffic volume and composition entered in IWRAP Mk II is usually obtained from AIS data. However, there may be several non AIS vessels such as fishing vessels and leisure boats in the area of interest. There is a certain probability of collision with such objects. This can be modelled with IWRAP Mk II by assuming a certain density of fishing vessels and leisure boats per unit area per year.

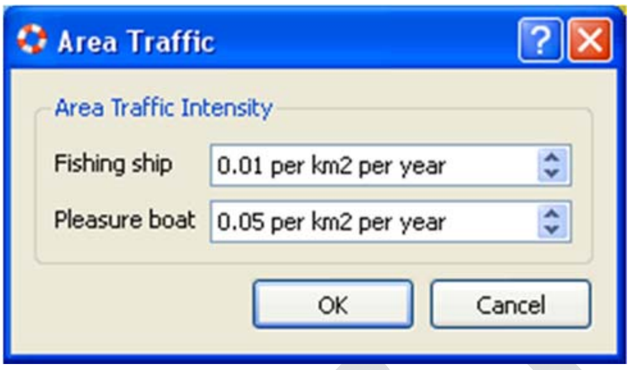

Figure 8 Example of specifying density of non-AIS vessels in a given area

This model is rather crude since it assumes a uniform density of such objects across the whole geographic region being modelled. However, it gives some idea of the risk of colliding with such objects.

2.6. SELECTING CAUSATION PROBABILITY FACTORS

A very important part of every IWRAP Mk II model, are the so-called Causation Factors used within the model. The Causation Factors can be thought of as the probability that the vessel fails to make an evasive action to avoid the grounding or collision. Several default factors have been selected as the IALA default Causation Factors and are presented in Table 1:

Table 1 IALA Default Causation Factors

Condition	Causation Factor
Head on collisions	$0.5 \cdot 10^{-4}$
Overtaking collisions	$1.1 \cdot 10^{-4}$
Crossing collisions	$1.3 \cdot 10^{-4}$
Collisions in a bend situation	$1.3 \cdot 10^{-4}$
Collisions in a merging situation	$1.3 \cdot 10^{-4}$
Grounding – forgot to turn	$1.6 \cdot 10^{-4}$

These factors have been carefully selected based on a careful literature study and are believed to be suitable as default factors and applicable in most parts of the world.

However, IWRAP Mk II allows the Analyst to modify these factors should that be desirable. If the default IALA Causation Factors are modified in a waterway model, the Analyst should state this fact in his/her report.

2.7. RESULT CALCULATION AND ASSESSMENT

Once the waterway model has been defined, IWRAP Mk II can calculate the resulting annual average collisions and groundings. The results can be displayed in tabular form as shown in Figure 9, or graphically, using colour coding as shown in Figure 10:

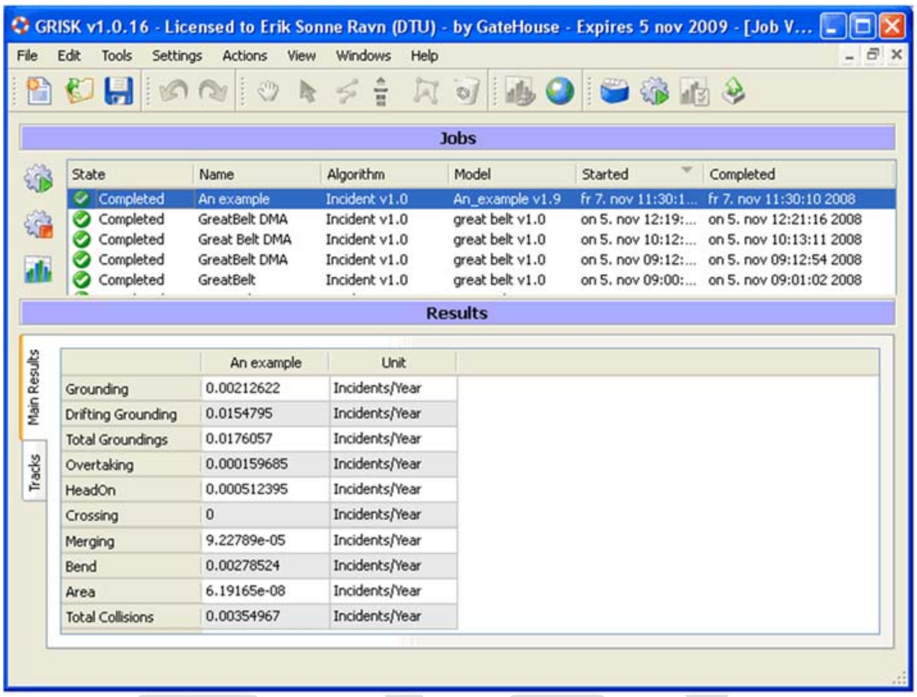

Figure 9 Tabular result view

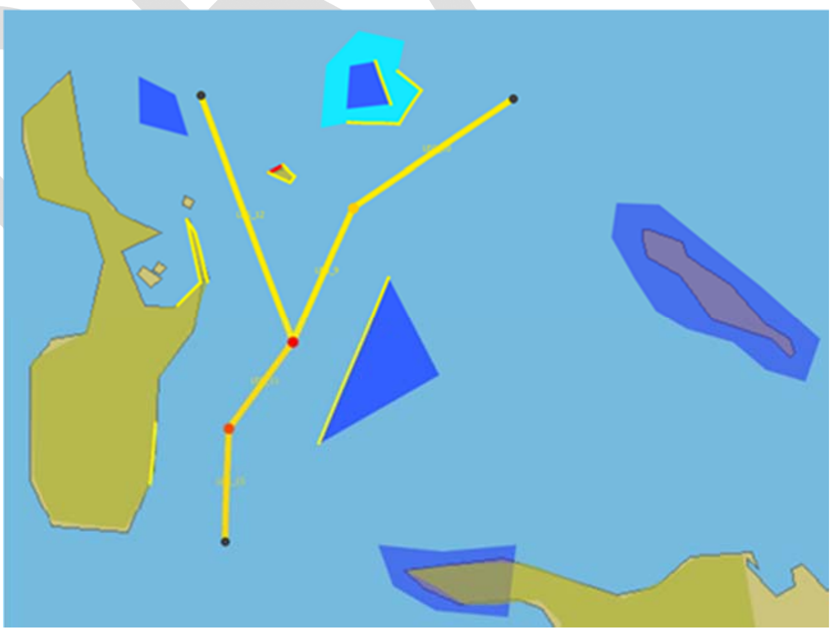

Figure 10 Geographical result view using Colour Coding

From the tabular result display (**Erreur ! Source du renvoi introuvable.**) the Analyst can assess what types of collisions and groundings are most likely to occur. From the geographical result display (Figure 8), the Analyst can assess where the collisions and groundings are most likely to occur.

Once a baseline result has been calculated, the Analyst can adjust the waterway model to account for any desired changes within the waterway. Several scenarios can then be compared to perform sensitivity analysis and evaluate different risk mitigating options.

IWRAP Mk II only addresses the *frequency* of collisions and groundings it does not consider the consequences associated with these incidents. It is left to the Analyst and the Authority performing the analysis to assess the possible consequences of the incidents, however, the output of IWRAP Mk II tool is well suited for such analysis to be performed subsequently.

3. THE NEED FOR TRAINING

IWRAP Mk II is an advanced, very flexible calculator useful for creating models of waterways and to analyse the level of risk expressed as incident rates in these waterways. The quality of the analysis is entirely in the hands of the Analyst, who must make a number of choices, such as selecting the route layout, estimate traffic density and distribution and select causation factors. Therefore, it is essential that the Analysts using IWRAP Mk II are properly trained and fully capable of understanding the implications of their choices