The Study of Warm Water Discharge into British Waterways Canal

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Introduction

- Using British Waterways canals as water cooling systems for industry and the commercial sector saves a over £100 million on energy bills and reduce carbon emissions by one million tonnes.
- On returning the heated water into the canal system the bulk temperature of the mixing zone which must not exceed 28°C - Environment Agency Regulation.
- Excessive increase in ambient water temperature reduces the dissolved oxygen which threatens fish life and other aquatic life-forms.

Aim

To develop a predictive tool that will determine the heat diffusion profile for heated water discharge into a body of still water. Such a predictive tool will allow British Waterways to accept more proposals for canal water use and so further reduce carbon emissions. The use of a thermal imaging camera to measure the discharge plume in conjunction with laboratory experiments, on site validation and software prediction tools allows the 3D mathematical model to be optimised for maximum effect.


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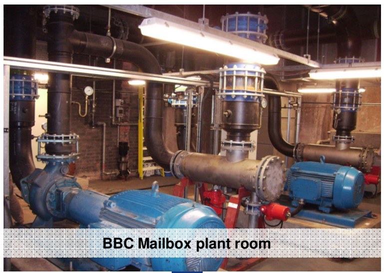
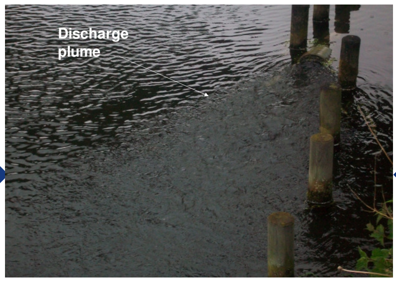

BBC Mailbox plant room

Cooling water discharge into British Waterways canal

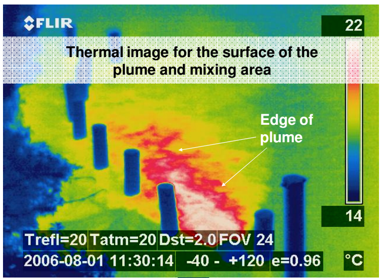
Cooling water discharge into British Waterways canal

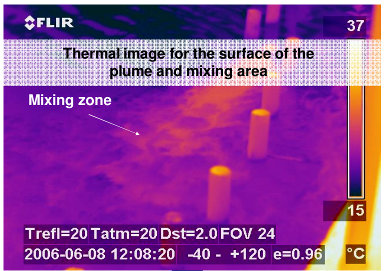


What size is the plume?

Plume from upstream

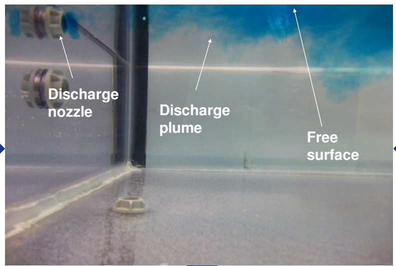
Plume from downstream





Coloured water shows the vertical extension of the plume

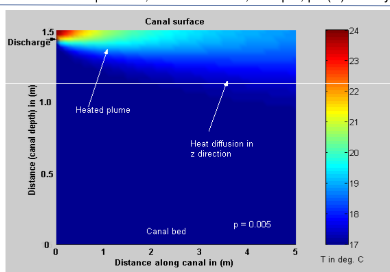
Experimental model tank shows the behaviour of the plume



$$T(x,y) = \left(\frac{To - Ta}{2}\right)\left(erf\frac{b-z}{2\sqrt{p1.x}} + erf\frac{b+z}{2\sqrt{p1.x}}\right) + Ta$$

To, Ta: discharge and ambient temperature, b: nozzle radius, z: depth, p1:(U)velocity/(D)diffusion Coef

Model applied on Matlab shows temperature distribution profile through the depth



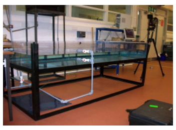
Mathematical model derived to predict temperature distribution through the depth

Methods

1. On site

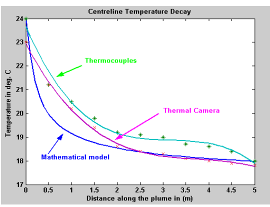
2. Thermal camera

3. Laboratory experiment



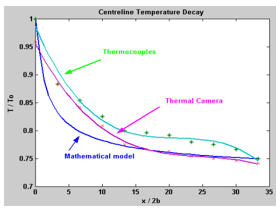
4. Mathematical model

$$U\frac{\partial T}{\partial x} = D_y\frac{\partial T}{\partial y} + D_z\frac{\partial T}{\partial z}$$



Results

The centreline temperature measurements by thermocouples on the site trial, along with the experimental data, are compared to the centreline temperature measured by the thermal camera and the data obtained by the mathematical model. The results are shown in the following figures where they are seen that the general form of the graphs are similar.



Conclusion

This work presents a novel study of thermal discharge into still canal waters. The technique makes use of a Thermal Camera to observe the heat distribution on the surface of receiving water and, using the s thermal images establishes the extent of the mixing zone. Mathematical models have been developed and optimised to correlate the temperature measurements on several selected canal sites and the results obtained from the 1/10th scale canal simulation laboratory test rig. This makes a serious contribution to improving emissions and sustainability.

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