



Bournemouth
University



Bourne Stream
Partnership

IS IT POSSIBLE TO IDENTIFY THE SOURCES OF NON-
POINT POLLUTION ADVERSELY AFFECTING WATER
QUALITY WITHIN THE BOURNE STREAM,
BOURNEMOUTH? CAN THE ISSUES BE ADDRESSED?

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Abstract

This research project aims to locate non-point sources of pollution which are adversely affecting the water quality of the Bourne Stream, Bournemouth, Dorset. As the stream discharges into Bournemouth bay any poor water quality affects the chances of Bournemouth Beach reaching the guideline standards of the EC Bathing Water Directive. This is important to Bournemouth Borough Council as these must be met to achieve Blue Flag status and increase the profile Bournemouth tourism industry.

Investigations have previously been carried out into point source and non-point source discharges using funding from the Environment Agencies Research and Development budget. Sustainable Urban Drainage systems have also been implemented but problems still occur suggesting that they must arise from a non-point source.

This project was based around chemical sampling of the stream water quality, allowing areas with regular or recurring issues to be identified. Once these areas had been selected the area around the stream was examined to find possible causes of the lowered water quality.

Water quality was tested for eight parameters on four different occasions, after statistical evaluation of the results three areas with problems were identified. None of these areas had the same problem during each sampling session but levels of determinands were high and seemed to reflect differing discharges.

Management techniques to deal with the problems have been identified based on the problem parameters and on cost versus benefits basis. These suggestions range from public education to the use of sustainable urban drainage techniques.

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Table of Contents

	Page
Abstract	i
Acknowledgements	ii
Table of Contents	iii
Introduction	1
• The Bourne Stream	1
• The Bourne Stream Partnership	2
• Aims and objectives	3
• History	3
• The Urban stream	4
• The Problem	5
• Previous work	6
• Urban pollution	7
• Effects of organic pollution	9
• Sustainable Urban Drainage	12
• Legislation used to improve the stream	13
Methodology	16
• Sampling site selection	16
• Current sampling points	17
• Choosing sampling points	19
• Description of sampling points	20
• Later sampling programmes	22
• Sample dates	23
• Selection of determinands	24
Results	31
• November 30 th 2003	31

• December 7 th 2003	33
• December 14 th 2003	35
• February 19 th 2004	37
Results Analysis	39
• Phosphates	39
• Nitrates	40
• Turbidity	41
• Dissolved Oxygen	42
• Temperature	43
• pH	44
• Conductivity	44
• Suspended Solids	46
Discussion	47
• Sample point one	47
• Sample point two	48
• Sample point three	48
• Sample point four	49
• Sample point five	49
• Sample point seven	50
• Sample point nine	50
• Sample point ten	51
Management options	52
Conclusion	55
References	57

NB: Appendices, and most Figures and Tables have been left out of this web-based version to keep the file size down. Please contact bournestream@aol.com for a full version on CD

Appendices	61
• Appendix I – Water quality law	61
• Appendix II – Photographs of Sampling points	63
• Appendix III – Raw Data	68

List of Figures

		Page
Fig I	Location of Bournemouth	1
Fig II	Path of Stream	2
Fig III	Oxygen sag curve	10
Fig IIII	Current sampling points	17
Fig V	Photo of mouth of culvert	19
Fig VI	Original sampling points	20
Fig VII	2 nd , 3 rd , and 4 th sampling programmes	23
Fig VIII	Photograph of oil covering the stream	43
Fig VIII	Photo showing plants and rubbish around the stream	48
Fig X	Photo of stream flowing through the middle gardens	Front Cover
Fig XI	Sample point one	64
Fig XII	Sample point two	64
Fig XIII	Sample point three	65
Fig XIII	Sample point four	65
Fig XV	Sample point five	66
Fig XVI	Sample point seven	66
Fig XVII	Sample point nine	67
Fig XVIII	Sample point ten	67

List of Tables

		Page
Table I	Categories of pollutants	8
Table II	The effects of eutrophication	12
Table III	Mean ranks from November 30 th 2003	31
Table IIII	Test statistics from November 30 th 2003	32
Table V	Mean ranks from December 7 th 2003	33
Table VI	Test statistics from December 7 th 2003	34
Table VII	Mean ranks from December 14 th 2003	35
Table VIII	Test statistics from December 14 th 2003	36
Table VIII	Mean ranks from February 19 th 2004	37
Table X	Test statistics from February 19 th 2004	38
Table XI	Raw data from November 30 th 2003	69
Table XII	Raw data from December 7 th 2003	70
Table XIII	Raw data from December 14 th 2003	71
Table XIII	Raw data from February 19 th 2004	72

Introduction

The Bourne Stream

The aim of this personal research project is to identify areas where non-point source pollution enters the Bourne Stream, which flows through Poole and Bournemouth close to the coast of Dorset, southern England.

The Bourne stream runs for 8 kilometres from the back of Poole down to the beach at Bournemouth. The path of the stream flows through many different landscapes from the wide open space of Canford Heath, through industrial and residential land down into the gardens in the centre of Bournemouth and out to sea.

Poole has a population of 138,000 (Office of National Statistics, 2003) and is a more industrial town than Bournemouth, particularly the north of the town which the stream flows through. For much of its length through Poole the stream is culverted.

Bournemouth is a large town with a population of 163,444 (Borough of Poole), it is fronted by seven miles of sandy beach and backs on to the beautiful Dorset countryside. Through Bournemouth the stream predominantly runs through gardens with residential properties backing on to it until it reaches the sea.

The Bourne Stream Partnership

The Bourne Stream Partnership (BSP) was formed in the year 2000, bringing together 11 local companies and organisations including the Environment Agency, Poole and Bournemouth councils, the two local water companies, the University and other conservation groups.

The main aims of the BSP are to improve access to the stream on foot and on bike, to improve the habitat of the stream and water quality and to promote the stream and local resident involvement. The Environment Agency employed MSc student Sarah Austin as the Project Officer to oversee the running of the partnership.

The BSP has already completed some projects working towards attaining a better quality stream. These have included the construction of reedbed wetlands at Alderney in 2000 and 2001 and operation stream clean in 2002 which identified and fixed sewage and grey water drain misconnections. In 2003 improvements were carried out to Coy Pond gardens which included the creation of a settling lagoon and flood basin. This was alongside a campaign to paint yellow fishes next to surface water drains to make people aware of where substances poured down the drain have an effect.

Aims and objectives

The main aim of this project is to find the areas of the Bourne Stream which are affected by non-point pollution and to suggest possible management options to solve the problem.

After discussion with the Bourne Stream Partnership project officer this project focuses on the western fork of the stream. This was because much of the current and previous research has focused on the Reed beds and water quality of the Eastern fork and effects on the stream water quality.

The research is based on primary sampling data which was carried out in November and December 2003 and February 2004.

The results will be analysed to find any locations with a regular water quality problem and whether there is an identifiable pollutant present. If any such areas or substances are found, the area around the stream at that specific location will be examined to either find obvious signs of pollutant entry or possible sources of the polluting substance.

The water quality and rainfall data will be used to produce an understanding of the Bourne Stream, it's inputs, it's main problems and to find out which substances are having a detrimental effect on the streams water quality and therefore the Bathing water quality of Bournemouth Beach.

History

The stream and its surrounding valley are historically significant in the area, having started to form after the last ice age 10,000 years ago. The Bourne runs over the Barton and Bracklesham beds which are formed of sands, clays and pebbles. The soil in the area is

clayey and sandy (Environment Agency, 1998). The stream consists of two main tributaries and has a drainage catchment of 12km². It is not designated as a main river so maintenance falls to the Borough of Poole and Bournemouth Borough Council.

There are many archaeological remains as the area was historically used for farming. This resulted in the clearing of forests around the stream creating a problem of acidic soil and the creation of the heathlands (Webber). Today the stream is still important as a site for both recreation and education, it is one of the few open and natural areas in the centre of Bournemouth and Poole. The location of the stream and its catchment can be seen in figure II (on page 1).

The stream runs through an area designated as an SSSI, a Special Protection Area and a local nature reserve at Alderney. The area is designated as these due to its importance as historic heathland and for the reptiles which are supported by it. The public gardens in Bournemouth, which the stream flows through, are designated as grade II* listed gardens. Historic gardens are seen to be a fragile and finite resource (Bourne Stream Partnership, 2003, II). The upper, lower and central gardens have also achieved green flag status which is awarded for cleanliness, sustainability and community involvement.

The Urban Stream

The Bourne is a typical urban stream as water quality in the stream suffers badly after heavy rain with the 'first flush' of water into the stream often being heavily polluted. The 'first flush' is the first run-off to reach a stream after an amount of rain-fall. It often contains bacteria and suspended solids as it flushes out accumulated pollutants from storm drainage systems and pavements. Chang et al defined the 'first flush' as being the first tenth of an inch of run-off, after this the accumulated store of pollutants on the pavement would have been washed away (Centre for Watershed Protection).

This is a problem faced by most urban waterways as there are many sources of run-off in urbanised areas, due to high numbers of impermeable surfaces, often carrying traces of heavy metals and chlorides from roads, and high levels of suspended solids.

The Bourne Stream faces another problem with this first flush as there are many surface water drains discharging directly into the stream, the 'first flush' from these often contains high amounts of bacteria and suffer from the anoxic conditions which are prevalent in roadside drain catchpits (Mason, 1991, p 49).

The Scottish Environmental Protection Agency has shown that 500km of river in Scotland has been polluted by substances delivered into rivers by surface water drainage (Environment Agency, 2002). This is also thought to be a problem in the catchment around the Bourne Stream as shampoo from car washing, engine oil poured down drains and sediment and grit washed off roofs and roads are all associated with residential areas like those which surround the stream.

The industrial areas around the stream are also thought to cause occasional problems with the water quality of the stream, as there is a confectionary factory and a dairy in the north of the catchment. These could be a particular problem as they are involved in industries which produce effluent containing high levels of organic waste, particularly high in nitrogen and phosphorous (Mason, 1991).

The culvert under the railway line has also been noticed as a problem (Sarah Austin, personal communication) as water quality problems have been noticed directly downstream of the culvert mouth. There have also been occasions where oily and emulsified substances have been seen in water with trails to the mouth of the culvert. Unfortunately due to the difficulties with access, little investigation has been possible into these problems.

The Problem

The pollution in the stream obviously has an effect on the areas surrounding it, both reducing the recreational value of the area and damaging the local area for wildlife that would otherwise rely on it.

One main problem is the location of where the stream discharges out to sea. Under normal conditions it discharges through a long sea outfall next to Bournemouth pier, this is an

important problem in the summer as the beach is particularly popular with tourists. The discharge is made worse under severe storm conditions when the excess streamflow has to be routed through a short sea outfall (approx twenty times per year) (Bourne Stream Partnership, 2003 (III)) and discharges are even more likely to be washed back to the beach.

Bournemouth Borough council are worried by the threat to their beaches Blue Flag status which they would like their beach to attain every year under the EC Bathing Water Directive. It has failed to achieve the guideline standards for this in 10 of the last 12 years, even though work has been carried out to reduce the point-source inputs.

Previous Work

As already mentioned, some work has already been carried out into the problems within the stream. In 2002 Kerry Fleet of Bournemouth University completed a project examining 'The use of constructed wetlands to improve the water quality of the Bourne Stream, Dorset'. She found that the constructed wetlands were not performing as well as expected and suggested that non-point sources of pollution could be affecting the efficiency of the system.

Joanne Hutt then carried out a similar study in 2003 examining 'The effectiveness of constructed wetlands as a method of pollution control at the Bourne Stream, Dorset'. She found that the wetlands had little effect on the microbiological content of the stream water and that there were also exceedingly high amounts of nutrients. Hutt also suggested that due to the high levels of bacterial content, there must be a source of faecal pollution in the area which would then have an effect on the quality of the stream all the way down to the sea.

Concurrent to this project Gary Broocks also of Bournemouth University is carrying out another study into the effectiveness of the wetlands and their ability to reduce levels of contaminants within it.

These three studies have all been focused on the eastern fork of the stream assessing water quality problems on this stretch. For this reason this study has been based on the western fork. The data used in these studies has investigated water quality almost up until Coy Pond and as no specific causes were found, it was felt surveying the eastern fork would be no help to this project.

Other work which has been carried out by the Environment Agency in monitoring the stream, is a scoping study for sources of pollution. This carried out in 1999 and 2000 and found very few sources of problems.

The Environment Agency also employed the consulting engineering company, Peter Brett Associates, to carry out assessments of the stream. This started in 1999 with a project titled 'Scoping Study for Surface Water Run-Off BMPs in the Bourne Stream Catchment' which evaluated the possibility of retro-fitting Best Management Practices to improve the stream quality.

In 2001 they were contracted to carry out two reports 'with the principal purpose of assessing the existing landscape, land use, habitat and wildlife conservation values and to identify options for enhancement'. These two similar studies were based on Coy Pond Gardens and the stretch of stream between Scott Road and Alder road. In 2003 they were contracted to compile a report identifying possible sites for source control measures within the catchment (Bourne Stream Partnership, 2003 (III)).

These more recent studies by Peter Brett Associates fit together with this study. They can be used together to assess the best possible placing for source control measures and Sustainable Urban Drainage Systems (SUDS) which are currently being planned by the BSP based on findings of water quality and locations of problem areas.

Urban Pollution

Pollution on some scale is unavoidable in any water course as polluting substances are constantly present in our environment, with almost anything produced by man able to be considered as a pollutant. Even some substances which are essential to life can become a

highly toxic pollutant when present in high amounts (Mason, 1991). There are 1500 substances which have been listed as pollutants in urban water-courses, and a generalized list can be seen below in, table I. Many of these substances are present in residential and commercial areas such as those surrounding the Bourne stream and therefore under run-off conditions threaten the water quality.

Table I – Categories of pollutants (From Mason, 1991)

General categories of pollutants found in fresh water
Acids and Alkalis
Anions
Detergents
Domestic Sewage and farm manures
Food processing wastes
Gases
Heat
Metals
Nutrients
Oil and oil dispersants
Organic toxic wastes
Pathogens
Pesticides
Polychlorinated biphenyls
Radionuclides

There are two main routes for pollution entering an urban stream, these are point-source and non-point source pollution. Point-source pollution is where pollutants enter the stream through a known and normally consented discharge. They include discharges such as surface water drains and industrial discharges, which would have specific locations which do not change. Significant investment has already been carried out ironing out any problems which were associated with the point-source pollution within the stream (Bourne Stream Partnership, 2003 (II)).

Non-point source pollution (also known as diffuse pollution) is the most difficult input to control. Rather than being discharged at a single location it enters the water course in a multitude of places over a wide area. This kind of pollution can enter the stream either through atmospheric deposition, contaminated sediments or more commonly through land use which results in wide spread run-off (Gray, 1999).

These diffuse sources of pollution can include surface run-off from hard surfaces, washout of fertilisers and pesticides from managed parks and gardens, sewage and industrial effluent entering the surface water drains through wrong connections, litter, transport accidents or illegal tipping of wastes (Environment Agency, 2002). Any of these non-point source pollutants could be present in the Bourne due to its location and surroundings, which contain many possible sources for these substances.

One source of diffuse pollution that is a particular worry in the stream (Personal communication, Neil Smith) is duck faeces originating in Coy Pond. If there are high levels of the faeces present then it leads to high concentrations of bacterial pollution in the stream and in turn in Poole bay.

Urban streams are also adversely affected by the urban areas surrounding them. These areas are generally constructed of large expanses of impermeable surfaces reducing the chance of water penetrating the ground and being naturally filtered as it percolates through. The lack of availability of soil for infiltration leads to run-off reaching streams and rivers much quicker than is natural, the speed of the run-off also causes a problem.

If a river has not increased above dry weather flow when polluted run-off reaches it then there is little chance for dilution and dispersion within the water-course (Mason, 1991). This is especially so within a stream like the Bourne which is 8km long with a gradient of 1:100 (Bourne Stream Partnership, 2003 (II)) and fast flowing. It results in very high levels of polluting substances flowing out to sea. This is thought to be the main factor causing the failure of Bournemouth Beach to meet the guideline standards in the EC Bathing water directive.

Effects of Organic Pollution

Because the majority of run-off entering the Bourne is likely to arise from household or commercial sources such as detergents, food wastes or organic matter carried in run-off. If high enough levels of organic pollutants are present, and begin to decompose then it can lead to oxygen depletion, eutrophication and nutrient enrichment. This has disastrous effects on any organisms that are supported by the stream.

Oxygen Depletion

When an organic effluent is discharged into a stream it exerts a Biochemical Oxygen Demand, with the processes of oxygen consumption and atmospheric reaeration occurring simultaneously (Gray, 1999). These are the main processes affecting oxygen status within a watercourse and can lead to oxygen depletion. It is a particular problem to water quality as all plants and animals rely on oxygen for respiration.

Oxygen depletion happens as micro-organisms act to breakdown the organic matter and use higher levels of oxygen. This decomposition is a natural process within a watercourse and an important supply of nutrients under normal conditions. A problem only occurs when the amount of organic substances is increased to a high level, as the substance decomposes its oxygen use can increase to greater rate than it can be replenished (Mason, 1991). This can cause an 'oxygen sag' as seen below in figure III, which relates to a pollution incident, although breakdown of organic material can have the same effect.

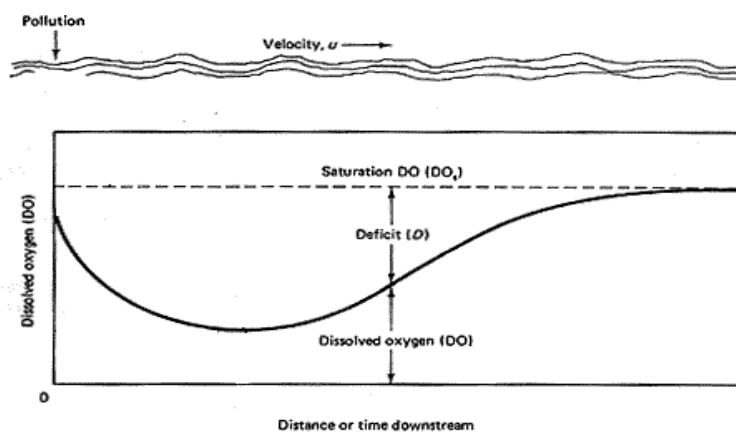


Fig III: Oxygen Sag curve (From Hong Kong University of Science and Technology, 2001)

Figure III shows the oxygen consumption exceeding the aeration rate soon after the pollution incident. As the rate of oxygen diffusion through the air-water interface is proportional to the oxygen deficit when the oxygen concentration declines the oxygen transport rate from air to water will increase. This leads to the lowest point on the curve where the rate of reaeration and oxygen consumption become equal. It is the most dangerous point of the curve as the oxygen concentration is at its lowest and the oxygen deficit is at its highest. From here reaeration becomes the predominant process as the oxygen concentration increases (Gray, 1999).

Concentrations of Oxygen less than 5mg/l can have an adverse effect on the functions of the river ecosystem and below 2mg/l most fish will die (Giller et al, 2002). Alongside the effects which decomposing organic organisms have on the oxygen content of water, organic effluents often contain large amounts of suspended solids which reduce the light available for plants photosynthesising. On settling they also cover the river bed and further starve organisms.

Eutrophication

Eutrophication is not currently regarded as a particularly important problem within the Bourne Stream. This is due to the steep gradient and high flow speeds, but with the addition of sedimentation ponds and extra meanders to slow the flow rate it is likely to become a more significant problem.

Eutrophication can be defined as 'the enrichment of waters by organic plant nutrients' (Mason, 1991). The effect of nutrient enrichment is to increase the rate of primary production, generally causing a large growth in the amount of algae present. Sometimes eutrophication can occur naturally but for the purpose of this report we are only concerned with artificial eutrophication caused by human activities.

The main problem substances leading to eutrophication and nutrient enrichment are nitrates and phosphates, this is because they promote the growth of algae which begins to starve the water of oxygen and lead to an increased rate of organic sedimentation. This happens because phosphate is normally a limiting factor in a water course, as it is naturally

only present in small amounts and algal growth is hence limited. Therefore an increase in phosphates will cause an increase in algal productivity. If a high amount of phosphate reaches the watercourse and nitrates become the limiting factor then some cyanobacteria which can ‘fix’ nitrogen will increase in growth provided phosphorous is not limiting, beginning to take over the stream.

Although an increase in production sounds like a good thing, table II below shows the effects of eutrophication on the receiving water body.

Table II: The effects of eutrophication on the receiving ecosystem and the problems to man associated with these (Taken from Mason, 1999)

Effects
Species diversity decreases and the dominant biota changes
Plant and animal biomass increases
Turbidity increases
Rate of sedimentation increases, shortening the life span of any lakes
Anoxic conditions may develop
Problems
Treatment of potable water may be difficult and the supply may have an unacceptable taste or odour
The water may be injurious to health
The amenity value of the water may decrease
Increased vegetation may impede water flow and navigation
Commercially important species may disappear

Sustainable Urban Drainage

The use of sustainable urban drainage systems (SUDS) is an important tool in trying to reduce the amount of pollutants entering a watercourse in urban areas. The idea was developed after water quality problems were attributed to our original system of separate storm drainage which allows rapid run-off from urban areas. The main polluting effects of this system are the rapid transmission of rainfall run-off into surface watercourses, contributing to urban flooding and damaging natural ecosystems, and pollutants are carried directly into the watercourse with no treatment.

The SUDS approach aims to:

- Avoid run-off if possible
- Slow the run-off process
- Manage run-off as close to possible to the point of origin

The SUDS idea is to allow rainfall and run-off to infiltrate the ground easily and allow storage within the ground, reducing and slowing the rate run-off flow. This keeps the water in as small an area as possible to reduce the amount of pollutants contained within the water and their transferral to other areas.

SUDS is the main technique being used in and around the Bourne Stream. Much of the funding comes from the Environment Agency's Research and Development budget. The Environment Agency are therefore using the Bourne Stream to test ideas so that they can later be applied to similar problems in larger watercourses.

SUDS which are already on use on the Bourne Stream are:

- Reed bed filtrations systems and wetlands at Alderney and South Park road pond.
- Drainage and water quality improvements at Coy Pond Gardens, which involved the creation of a settling lagoon and water meadow, along with a weir structure and splash pool.
- Yellow Fish campaign which involved painting fish next to surface water drains to encourage locals to remember where the water goes.

This can be achieved by using permeable surfaces on any hard standing surfaces to allow slower infiltration of the run-off through the ground, allowing natural filtering and more settling time whilst recharging the groundwater.

Legislation Used to improve the stream

There are many different sets of water quality legislation which relate to different substances and different organisms within a watercourse. All environmental legislation

arises from either EC directives or UK law, it generally relates to either inland watercourses or the sea.

The main legislation relating to the Bourne Stream is discussed in detail below including the Water Resources Act 1991, EC Water Framework Directive and the EC Bathing Waters Directive. Further legislation relating to water quality and the environment associated with watercourses is included as Appendix I.

The Water Resources Act 1991

The Water Resources Act (WRA) was introduced in 1991 replacing the corresponding sections of the Water Act 1989 and consolidating all of the previous legislation. The main purpose of the Act was to set the responsibilities of the National Rivers Authority (NRA) relating to water pollution, resource management and flood defence, it also introduced the idea of the 'polluter pays' principal.

The act also introduced the idea of the NRA regulating discharges to water and section 85 of the Act states 'no person shall cause or knowingly permit any poisonous, noxious or toxic material or solid waste to enter a controlled water'. This does not include any discharges released under consent but can result in a fine of up to twenty thousand pounds (Envirowise, 2000).

The Environment Act 1995

The NRA was replaced by the Environment Agency (the Agency) in the 1995 Environment Act, this brought together the NRA, Her Majesty's Pollution Inspectorate and some waste responsibilities from local authorities. Section four of the act states the aim of the Agency is to 'protect or enhance the environment taken as a whole, as to make the contribution towards attaining the objective of sustainable development' (HMSO, 1995).

In the sense of water the three main aims of the Agency are to generally promote 'the conservation and enhancement of the natural beauty and amenity of inland and coastal waters of land associated with such water', 'the conservation of flora and fauna which are

dependent on the aquatic environment' and 'the use of such waters and land for recreational purposes'.

The Agency can charge for abstractions and discharges, and they can also set strict limits for levels of substances within discharges with heavy fines being imposed if limits are broken.

EC Water Framework Directive 2000

The EC Water Framework Directive (2000/60/EC) (WFD) was introduced in 2000 it is the most substantial piece of EC water legislation to date (DEFRA, 2001). The WFD requires all inland and coastal waters to reach "good status" by 2015.

This will be achieved by establishing a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which prevents further deterioration and protects aquatic ecosystems. It promotes sustainable water use, aims at enhancing and improving the aquatic environment and ensures the progressive reduction of water pollution. It will do this by establishing a river basin district structure within which demanding environmental objectives will be set.

EC Bathing Waters Directive 1976

The EC Bathing Waters Directive was one of the first pieces of European Environmental legislation. It was designed to protect public health and the environment from faecal pollution of bathing waters. Obviously this piece of legislation doesn't apply directly to the Bourne Stream but it is worth considering as the Bourne Stream does have adverse effects of Bournemouth and Boscombe beaches passing the 'guideline' standards which are required to receive the prestigious Blue Flag award (Environment Agency, 2000).

The Bathing water directive was probably the main legislation behind the formation of the Bourne Stream Partnership, as after failure in ten out of the last twelve years Bournemouth Borough Council and the Environment Agency realised that they had a serious problem which needed investigating. This project fits into this work by trying to establish the

locations of discharges which are having a detrimental effect on the stream and possibly bathing water in Bournemouth Bay.

Methodology

Sampling Site Selection

Before any field sampling is carried out it is important to define the objectives of the sampling programme (Gray, 1999). In defining the sampling programme there are seven useful questions to consider (Wilson, 1974):

- What are the objectives of the programme?
- Which determinands are of interest?
- Where and when samples are to be taken?
- How samples are to be taken?
- Which analytical measures are to be used?
- How are the results going to be reported?
- What is going to be done with the reported results?

The objectives of this project have been discussed in the introduction as investigating sources of non-point pollution within the Bourne stream. This was achieved using chemical sampling techniques as equipment for testing is available from Bournemouth University.

The testing equipment which was available for the study set how the samples were taken. It involved on-site testing using colorimetric or chemical tests. A discussion of the chosen determinands appears later in this section of the report.

Samples were analysed using the statistical computer package SPSS, therefore they are reported as tables and graphs. Each sampling programme was analysed using the non-parametric Kruskal-Wallis Test. This allowed different substances to be compared

together, making it possible to locate sampling points with high levels of a number of substances.

Current Sampling Points

The sampling points currently sampled by the Environment Agency have been used as a basis for the sampling points used in this research project. The current sampling is carried out by the Environment Agency with analysis of the samples being carried out by Bournemouth and West Hampshire Water. The sampling points were chosen by the Environment Agency and Sarah Austin, The Bourne Stream Partnership Officer.

The eight sampling points chosen for this study are shown in the later Sampling Points section of this report. The sampling programme only covers the western fork and main channel of the stream after the two tributaries meet. This pattern of sampling was chosen after discussion with Sarah Austin on the 10/11/03, the reasons for this are explained below.

Although the precise location of the sampling points could not be confirmed until an examination of the sites was carried out, relevant areas were chosen to be examined at the time of the first sampling programme so that specific sampling points could be chosen.

This section of the stream was chosen as many studies have already been carried out examining the effectiveness of the SUDS which have been created on the eastern fork. There have been improvements in water quality but not as much as hoped, this suggests that there are significant inputs of pollution on the western fork of the stream.

There are many areas of the western fork where non-point pollution could enter the stream, such as a possible source of detergents originating from cleaning practices at Rossmore Community College, where any dirty water poured down surface water drains would enter the stream at one of its shallowest and smallest points. Another suspected source of detergents is 'wrong connections' from domestic properties (Personal conversation, Dr Neil Smith), this often happens when an extension is built or when a new water using appliance is installed incorrectly.

The presence of a confectionary factory and a dairy on the western fork of the stream are also seen as a threat to water quality within the Bourne, due to the high amounts of organic waste which could originate from these practices. If even small amounts of these substances entered the watercourse the Biochemical Oxygen Demand (BOD) would increase and oxygen content would decrease. This is because micro-organisms use oxygen whilst breaking down organic material.

Another area of concern on the western fork of the Bourne Stream is a culvert running under the Bournemouth to Poole railway line, this is a problem as it is not possible to effectively investigate the culvert due to its size and proximity under the railway line. Any mis-connections in this area can only be easily identified through sampling the mouth of the culvert. This would not provide any indication of the source of any pollutant.

The photo below shows an incident on the 11/11/03 where a white emulsified substance entered the stream. It was originally thought to originate from the dairy, a decorator or the confectioners. The photo also shows the problem of access to the culvert.



Fig V: Mouth of the railway culvert (Taken by Austin, S)

Choosing Sampling Points

‘Choosing the correct number and location of sampling points is critical if the necessary information is to be gained’ (Gray, 1999). This means a lot of thought needs to be put into choosing correct sampling points, making sure that they are representative of the true water quality. Although this is important, whilst choosing sampling points it is also necessary to consider the information which will be gained against the cost-effectiveness of the programme.

If the objective of a project is to examine changes in water quality caused by a single point-source then only two points need to be chosen, a control point above the discharge and a station downstream of complete mixing. Whereas if the objective is to monitor a whole catchment, then a considerable amount of sampling points will be required to provide an understanding of the whole stretch of water.

For this project four sampling programmes were carried out, the first one featured ten points based downstream of main roads which intersect the Bourne and at other sites representing important stretches of the stream these can be seen in fig VI below. For the next three sampling programmes the amount of sampling sites was reduced to eight. The number was reduced as it was decided that ten points was excessive for the length of the stream.

Description of Sampling Points

Sample Points one and two were chosen to sample the water quality as it first flows out of the groundwater. Each point represents the very start of the tributaries which form the western fork of the stream. It is thought that some road/ car park run-off is entering here and it is a possibility that detergents are regularly being poured down the surface water drains. These points showed any problems with water quality before any significant discharges enter the watercourse.

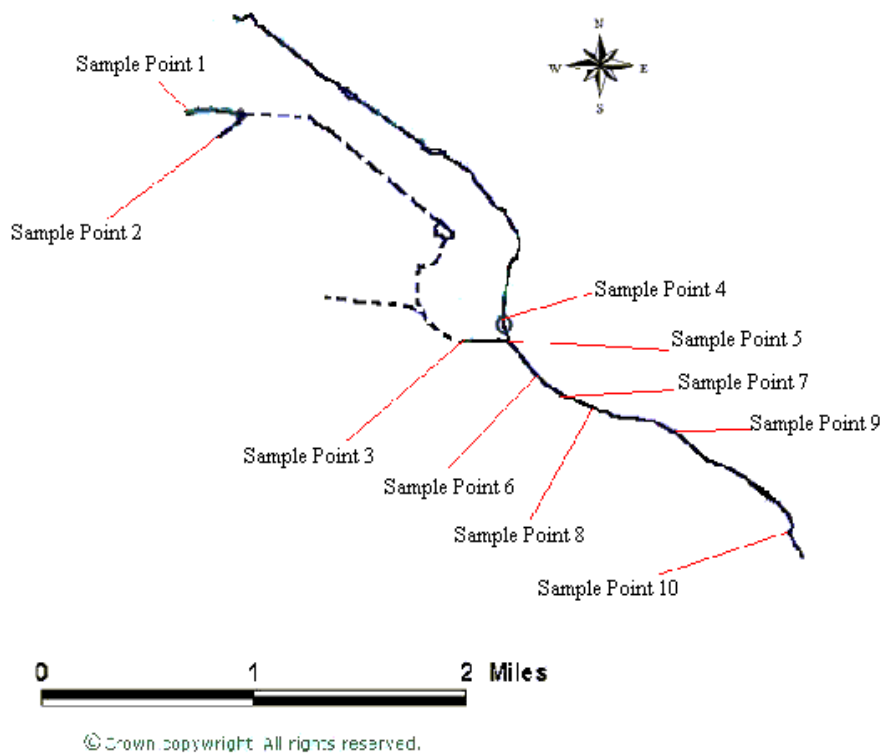


Fig VI: Original Sampling Points (Adapted from Bourne Stream Partnership, 2003 (V))

Sample Point Three was chosen to represent the water quality as the stream emerges from the culvert under the railway line. Any problems in water quality here are hard to attribute to a specific source as there is no exact record of flows into the culvert. Pipe work above the culvert could be damaged which would allow substances to enter the stream uncontrolled through the soil.

Sample Point Four was chosen as it is the point at which the flow from the eastern fork of the stream reaches Coy Pond, this is a man-made settling area. Results from these samples will show if there is a significant problem with quality in the water entering from this fork of the stream. It is unlikely that any pollutants entering Coy Pond would reach the stream in one go due to the settling and mixing qualities of the pond which should slow down and reduce polluting effects. However any accumulation of substances may have an adverse affect on the fish and wildlife of the pond.

Sample Point Five is located at the area of convergence of the water in the eastern and western forks of the stream. This is almost a control point as it establishes if any problems are emanating from the forks which form the stream, or whether problems begin below this point.

A possible problem in this area is micro-biological pollution from the large duck population of Coy Pond. However it would be ineffective to sample for biology in this area but not at the other sampling points, as there would be no locations to compare results with. Any significant problems will still be shown by chemical sampling, as high levels of organic pollutants such as nitrates and phosphates are also an effect of animal faeces.

Sample Point Six was downstream of Branksome Wood Road, this was chosen as it is downstream of one of the main roads crossing the stream. This is likely to be a source of some run-off as the road runs up and down the valley sides either side of the stream. There are two large discharge pipes under the road bridge, which could be a source of heavy metal and oil based pollutants.

Sample Point Seven was chosen downstream of Prince of Wales Road, this is the second largest road crossing the stream and carries large amounts of traffic. Again the road runs up and down the valley sides which may increase road run-off. There is also a pipe discharging liquid with an accumulation of an iron like substance around its mouth.

Sample Point Eight is downstream of Queens Road so run-off from the road could be a problem. Three discharges and a covering of sewage sludge were noticed during an observational walk along the stream.

Sample point Nine was chosen downstream of Wessex Way and the Bournemouth Tennis Centre. Wessex Way is a dual carriageway which acts as the main road between Bournemouth and Poole. Traffic is very heavy along this road, particularly during rush-hour which could lead to a large amount of heavy metals and suspended solids in any run-off. The tennis courts also provide a large expanse of concrete which reduces ground percolation and increases run-off. This problem is added to as there are large amounts of organic matter in the area due to dog walking and leaves, which could enter the stream and contribute to eutrophication as substances break down.

Sample Point Ten was chosen as the last sampling point along the stream. The water here has flowed directly under the town square which may increase the chances of unknown discharges whilst the stream is culverted. Due to the large expanse of impermeable ground in the town centre there could also be a large amount of run-off entering upstream of this point. This is also the closest point (other than culverts) to where the stream discharges into the storm tanks and sea outfall so represents the water quality as it enters the sea.

Later Sampling Programmes

After the first sampling run it was found that it was possible to slightly reduce the number of sampling points. This was possible as points could be dropped which did not represent any significant change in water quality. The reduction of sampling points also reduced the time required for sampling and increased the efficiency of the programme.

The points which were discarded were sample points six and eight. It was felt that the original results from these locations showed very little change from sample point seven at Prince of Wales Road. Therefore this would suggest that there is little chance of any non-point pollutant sources in this area. Fig VII below shows the sample points which were used for the final three sampling programmes.

Sample Dates

The sampling dates were originally selected as the 30/11/03, 07/12/03, 14/12/03 and the 21/12/03. Unfortunately due to work commitments and transport problems the sampling programme on the 21/12/03 had to be postponed until the 19/02/03.

Fortunately this did not damage the integrity of the findings as it provided data from later in the season when more activity is likely to be occurring around the stream.

Samples were taken at as close to the same time as possible on each day with the sampling programme starting at the same time each cycle. The sampling strategy provided four 'snapshots' in time of water quality, this will allow the quality of water to be analysed

against each other. This provided an idea of the water quality whilst different activities were occurring in the area, allowing areas with persistent problems to stand out.

Selection of Determinands

The selection of parameters for water sampling depends on the type of receiving water, the nature of any discharges, water use and any legislation relevant to the watercourse.

Parameters which are regularly used for river water quality sampling are Biological Oxygen Demand (BOD), oxygen, temperature, nitrates, chlorine, phosphates and nitrogen (Gray, 1999). Although these are not all of the parameters which require sampling, they are widely representative of river water quality in a recreational and managed environment.

There are two general types of chemical analysis determinands. These are specific water quality parameters such as testing for nitrates and phosphates, or non-specific water quality parameters. The latter are determinands of common interest that correspond to a group of substances (Allen and Mancy, 1972), examples of these are BOD, conductivity and suspended solids. The levels present have no independent existence and are not dependant on a specific substance.

Unfortunately for this personal research project the choice of determinands was generally governed by University equipment and it's availability. This resulted in the chosen parameters being a selection of specific and non-specific parameters covering the basic substances associated with pollution in urban areas.

Eight testing parameters have been selected for use based on the availability of sampling equipment and determinands which will be useful for assessing water quality in association with investigating sources of pollutants. Each chosen parameter is discussed at length below explaining the reason for testing.

Also included in each section is an explanation of the method used to sample each parameter. Each determinand was sampled three times at each sample point so as to account for any errors throughout the sampling programme.

pH

One of the non-specific parameters is pH, testing for the acidification of water. pH is the measure of acid balance of a solution. In unpolluted water pH is controlled by the balance between carbon dioxide, carbon and bicarbonate ions (Gray, 1999).

pH was tested in situ using a Camlab ISFET pH meter, model number KS701, the meter was calibrated with a pH 7.0 buffer solution before each measurement was taken.

Acidification of watercourses can occur through either non-point sources such as acid rain run-off, caused by sulphur dioxide and nitrogen oxide emissions, run-off from agricultural land which has been treated with fertilisers or road run-off containing metal and fuel traces.

There are no real areas of agricultural land surrounding the areas of the Bourne stream that this report focuses on, but it does run through the acid heathland of the Bourne Bottom Nature Reserve which will increase the acidity of the water. The pH level in a normal river or stream is expected to be just below seven. Slight deviations around this figure do not cause a problem to most organisms and the level is usually controlled to a small amount by the local ecology.

If the pH value changes significantly then it begins to cause problems with respiration and photosynthesis as most plants and animals find it difficult to survive under heavily acidic or alkaline conditions.

Temperature

This is another non-specific parameter however it is linked to dissolved oxygen levels as the warmer the water the less oxygen can be absorbed. Obviously there are seasonal temperature changes within a watercourse, especially during the summer and winter, but most organisms are equipped to cope with this. There should be no sources of thermal pollution along the Bourne stream, but due to its link with absorption levels of the water and effects on biology it still requires consideration.

Temperature was measured using a Hanna Instruments Minnitherm, model HI8751 with a range of -40°C to +150°C. This simply required the insertion of a probe into the water and taking the reading from an LCD screen.

If there is a source of heat pollution then there are various effects which it could have on the biology of the stream water. Species intolerant of warmer water may disappear, productivity of algae would be likely to increase and feeding, breeding and growth patterns of current organisms may be heavily altered (Mason, 1991).

Dissolved Oxygen

Dissolved Oxygen (DO) was tested using a Hanna Instruments Ion Specific Dissolved Oxygen meter, model 93732. This is a microprocessor based DO spectrophotometer. The meters operation is based on the Winkler method where the reaction between the sample and a reagent makes it possible to measure the amount of electronic radiation absorbed by the sample.

The process involved filling a 10ml cuvet with unreacted sample to zero the meter. Once zeroed a 60ml BOD bottle was rinsed and filled with the sample, ensuring no oxygen was left in the bottle. Five drops of reagent HI 93732A was added followed by five drops of HI 93732B. The cap was then replaced, ensuring no oxygen was left in the bottle, the solution was swirled and then left for approximately two minutes until the upper half of the sample became limpid. After this ten drops of HI 93732C was added and the sample was swirled. Another cuvet was then filled with 10ml of the reacted solution and placed in the meter, the concentration of dissolved oxygen was shown on the screen in mg/l (ppm).

This again is a non-specific parameter with levels being affected by temperature, pressure and dissolved minerals within the water. Oxygen is essential to all aquatic organisms as it is required for respiration and growth.

There are two main ways that oxygen molecules are received into water, the first is by diffusion through the air-water interface where they are dissolved, the second method is through oxygen being released into the water by plants photosynthesising.

If there is a high level of salts from road run-off then this will inhibit the saturation concentration of oxygen and lower levels will be present. Fresh water at 1 atmosphere of pressure and 20°C should contain 9.08g of O₂ (Gray, 1999).

Conductivity

Again a non-specific parameter, conductivity is a measure of water's ability to conduct electrical current. The ability to conduct electricity comes from ions in the water, these are atoms of an element which have gained or lost an electron. It is also linked to the concentration of mineral salts in the water.

This was measured on site using a Hanna Instruments conductivity meter, model DiST WP. The range was 0 – 1999 $\mu\text{S cm}$ and a reading was taken by placing the meter in the stream and reading the result. The meter was self-calibrating with automatic temperature compensation (Enviroequip).

Conductivity is measured in micro-siemens per centimetre ($\mu\text{S cm}^{-1}$). It is regularly used to measure pollution as natural rivers and lakes should have a conductivity value of between 10 and 1000 $\mu\text{S cm}^{-1}$. Levels above 1000 $\mu\text{S cm}^{-1}$ are a definite sign of pollution (Gray, 1999).

Due to the presence of four busy roads which cross the Bourne, any high levels of conductivity are likely to be linked to the presence of road run-off from gritting and other associated particles. The main effects on the conductivity of water are the concentration or number of ions, mobility of the ion, oxidation state and temperature of the water (South Dakota State University).

Suspended Solids

This is again a non-specific parameter and is generally linked to conductivity. Although a separate meter was used in this research it is possible to multiply the conductivity value by a specific factor to reach the same result.

Measurements were taken using a Hanna Instruments TDS model 1 meter with a range of 10 -1990 ppm TDS. Readings were obtained by placing the meter in the water and multiplying the reading by ten.

High levels of suspended solids could lead to silting up of the stream bed and problems with respiration. There are also indirect effects with the elimination of desirable food plants and habitat-forming plant species which are relied upon by organisms within the stream.

Possible source of suspended solids along the Bourne Stream are road run-off containing grit and traces of heavy metals. A problem could also occur if large amounts of organic solids are discharged from one of the food producing factories.

There may be some high levels of suspended solids on certain sampling days at sample point five as work was being carried out in Coy Pond gardens. This left large amounts of loose soil around the stream which may have entered the watercourse. Soil erosion caused by fast or high flows could also contribute to high levels of suspended solids.

Turbidity

Turbidity was measured using a Hanna Instruments C114 turbidity and chlorine meter. Results were tested using the nephelometric principle. No reagents were required and the range was 0.00 to 9.99NTU & 10 to 50NTU (Hanna Instruments, 2003)

It is a test of how clear water is, it is another non-specific parameter. Reasons for high levels of turbidity could be caused by turbulence, bank erosion, resuspended bottom sediments or organic discharges from stream or wastewater discharges (Water on the Web).

High turbidity concentrations can lead to reduced light penetration, which in turn can lead to reduced rates of photosynthesis, can cause shallow rivers to silt up and can suffocate habitats and organisms as it settles out.

High amounts of turbidity will be located in locations where there are high levels of suspended solids and conductivity.

Nitrates

Nitrate is the first of the specific parameters as it only investigates one substance. Nitrates are soluble in water so would not show up in tests for conductivity or suspended solids.

It was measured using a Hanna Instruments Ion specific Nitrate meter, model HI 93728 with a range of 0 – 30 mg/l.

Results were obtained by filling a 10ml cuvet with unreacted sample and using this to zero the meter. A packet of HI 93728-0 Nitrate reagent was added and the sample was shaken for one minute. The reacted sample was then placed in the meter and read after four minutes and thirty seconds. Results were displayed in mg/l of nitrate-nitrogen, to change this into mg/l of nitrate (NO_3^-) it had to be multiplied by 4.43 (Hanna Instruments, 1998).

Inorganic nitrogen may exist in a free state as a gas (nitrogen), or as nitrate, nitrite, or ammonia. But the equipment available will only test for nitrates.

Reactions of nitrates in water lead to oxygen depletion which can lead to death of plants and animals as there is not enough oxygen present in the water.

Nitrate levels of less than 0.5mg/l are known to cause no problems for fish (Kentucky Water Watch).

Phosphates

Phosphates were tested using a Hanna Instruments Ion Specific HR Phosphate meter, model HI93717. The meter had a range of 0 – 30mg/l and uses an amino acid method.

The process began with filling a cuvet with 10 ml of unreacted sample, this was used to zero the meter. 0.5ml of HI93717A Molybdate reagent was then added into the sample along with 0.5ml of HI93717B Amino Acid reagent, the solution was swirled. The reacted sample was then replaced in the meter and it was set to 'Read Timed'. This set the meter

on a five minute cycle, displaying the concentration of phosphate in mg/l (ppm) on the screen.

Phosphates themselves are not toxic to animals or plants. Phosphate is a nutrient which increases plant growth and can lead to the processes of eutrophication, through the over production of algae and waterweeds.

One main source of phosphates in water is detergents which may enter the Bourne through mis-plumbed washing machines and cleaning effluent being poured down drains. Another source of phosphate which may well be a problem in the Bourne Stream is the run-off of phosphate based fertilisers from parks and gardens, such as the upper, lower and central gardens in Bournemouth.

Phosphate in water is often bound to the soil particles which it has been spread on for weed control. It has been found that run-off from street gutters kept clean of plant materials have 30-40 percent lower content of phosphates than those which have had contact with plant materials (University of Minnesota, 2001).

Results Analysis

Within this section the results from the statistical tests (shown in the previous, Results section) have been analysed, this has been used to highlight the problem areas.

Phosphates

Unfortunately due to defects with the phosphate meter during the first sampling session (30/11/03) there were too few results to be analysed using the Kruskal- Wallace test, therefore they have been left out of the analysis.

During the second sampling session there were high levels of phosphates at Sample Points (SP) one and two, this suggests that phosphates are emanating from within the groundwater of the area. The level was also high at SP ten which may suggest that there is a source of phosphates in the town centre.

As the majority of businesses in the town centre are shops it is unlikely that this originates from them, it seems more likely that it may arise from pesticides or fertilisers which have been applied in the lower gardens.

During the third sampling session high levels of phosphates were found at SP's four and seven. SP seven is in the middle gardens, as the levels of phosphates at the surrounding sample points is not high it would suggest there is a direct input in this area, possibly entering through the surface water drains. Due to the number of residences along the banks in this area it is also possible that there is a domestic misconnection resulting in washing machine discharges entering the stream with high levels of phosphates present in detergents.

SP four is at the point where water from the eastern fork enters Coy Pond, there must be a source of phosphates upstream of this point, especially as Hutt (2003) found that the Reed beds which have been installed did little to reduce the amount of phosphates contained in the water.

Unfortunately on the fourth sampling session the phosphate testing kit failed again, leading to too few results to be effectively analysed.

Nitrates

Due to the unreliability of the testing equipment there were not enough results to analyse the levels of nitrates on the first sampling day.

The level of significance for nitrates on the December 7th was .003. This makes the readings highly significant when compared with other substances. On the same day there were high levels of nitrates at SP's one, three and five. SP three is the sample point directly after the railway culvert into which the flow from SP's one and two feeds. Therefore the high levels at SP's one and three are likely to be related, showing a high level even after a long distance.

SP five may have a high reading due to the presence of large amounts of duck faeces from the population in Coy Pond. This theory is backed up by the slightly lower level at SP seven after more mixing has occurred.

On December 14th there were high levels of nitrates at SP's one, two and seven. Again the problems at SP's one and two are likely to emanate from the groundwater. The high levels at SP seven may come from either a domestic misconnection or the surface water drain discharging into the stream upstream.

The fourth sampling session on February 19th showed high levels of nitrates in areas which had shown problems during previous sessions, these were SP's one, two, five and seven. The levels at SP's one and two do suggest that there are serious problems before the stream enters the open air, however part of this problem could be linked to shallow water allowing little mixing.

The high level at SP five could again be attributed to duck faeces originating from Coy Pond, again backed up by the slightly lower level downstream at SP seven after more mixing has occurred.

Turbidity

On November 30th the highest levels of turbidity were at SP's one, two, three and ten. The readings at SP's one and two could probably be attributed to the shallowness of the water in this area.

The main reason for the high turbidity level at SP three is probably the works which were being carried out just upstream of the sample point although it could also be linked to the high levels at SP's one and two.

The high level at SP ten could be caused by any of three problems, the small weirs at the start of the lower gardens, the culvert under the square or the contents of surface run-off from the gardens and square. The significance of turbidity was 0.001 which shows it to be very significant possibly meaning particles of other determinands are attached to sediments.

The highest levels of turbidity on December 7th were at SP's seven, nine and ten. Due to the locations of SP's seven and nine downstream of roads it is likely that the high content may arise from surface run-off. As the turbidity level is high at sample point ten again it suggests that this may be a problem spot.

On the fourteenth of December the testing equipment stopped working part way through the session so there were not enough results to be analysed effectively.

The highest levels of turbidity February 19th were at SP's one, three, nine and ten. The high levels at SP one can again be attributed to either the content of the water as it emerges from the ground or the shallowness of the water in this area. Although the construction just above SP three had finished by this session the soil around the stream was still un-compacted and very wet so erosion was probably the cause.

Dissolved Oxygen

On November 30th the levels of Dissolved Oxygen (DO) were low at SP's six and nine. SP nine was particularly low with a mean rank of 3.00 this is the sample point directly downstream of the tennis courts, it is a popular location for dog walkers and is covered by trees which may create large amounts of organic pollution.

There were also traces of sewage sludge in this location on previous inspections of the stream. The significance of the dissolved oxygen was .005 on this day making it highly significant and linked to the other determinands.

On December 7th the DO meter only worked for SP's seven, nine and ten. Each of these points did show low mean ranks particularly at SP seven.

The third sampling session showed extremely low levels of DO at SP three, this could possibly be attributed to the new soil which had been landscaped around the stream containing high levels of organic matter and therefore consuming large amounts of oxygen.

There were also relatively low levels of dissolved oxygen at SP's five and seven. SP five was likely to show low levels as it is just downstream of the mixing point of water from SP three and Coy Pond. SP seven is downstream of a main road which has showed elevated levels of other substances and may be linked to this.

On February 19th there were very low levels of DO at SP's two and seven. The low level at SP two was possibly linked to a covering of oil on the water, shown in figure VIII below this seemed to be emanating from work being carried out by Transco engineers on the upstream road.

The low level at SP seven added to the evidence suggesting that there is either a problem with the quality of the surface water entering at this point or there is a regular non-point source of pollution.

Temperature

On November 30th the temperature was fairly stable along the whole stream, other than a slight rise at temperature at SP three. There was also a small drop at SP four where the water enters Coy Pond, this was probably caused by the water mixing with a large area of shaded standing water.

During the second sampling session the water was warm at SP's one and two, with the temperature being just over ten degrees Celsius. There was a large drop at SP four with the temperature reducing to around 6°C before the results levelled out around 8° for the rest of the stream.

On December 14th the highest results for temperature were found at SP's one and two, both recorded results of over 11°C with the rest of the stream measuring between 9° and 10.4°.

The fourth sampling session mirrored the temperature results from the first three sessions with high readings at SP's one and two, before settling out between 8° and 9°C. The high temperatures at these sample points may be due to the shallow water level allowing fast warming by the sun.

pH

The pH levels during the first sampling session were fairly steady along the whole stream. There were slightly higher levels at SP's one, two and three, probably caused by the slightly acidic soil which the water previously flows through. The readings were lower at SP's five and seven where the mean level was around pH 6.8.

On December 7th the pH was fairly constant ranging from 8.2 to 6.7 with the highest mean levels at SP's three and ten.

The third sampling session again showed fairly constant results the whole length of the stream with pH ranging from 6.8 to 7.6. The highest means were found at SP's one, four and ten. The lowest means were found at SP's five and seven.

The results from February 19th showed the highest mean numbers at sample points two and three, with means of around pH 8.2 at both of these points. The levels of pH then levelled out at around 7.5 along the rest of the stream.

Conductivity

During the first sampling programme there were very high levels of conductivity at SP's four, five, eight, nine and ten. Due to the proximity of these sampling points it is probably fair to come to a conclusion that the levels at SP's four and five and then eight, nine and ten are linked together.

As conductivity is low at SP three it is possible that the majority of the minerals causing elevated levels enter the main body of the stream through the eastern fork. This is surprising as it is a problem that the reed beds are designed to deal with.

As SP's eight and nine were downstream of main roads it is possible that road run-off, after gritting, was the cause of these high levels. These high levels are also likely to be linked with the high conductivity at SP ten as they are both upstream. It is also possible that raised levels may be caused by gritting the town square or run-off from the roads which merge in the square.

On December 7th the highest levels of conductivity were at SP's three, five and nine. SP three is surprising as this is downstream of the railway culvert and has no significant roads present, this high level is likely to have caused the elevated reading at SP five which is the mixing point below SP three.

The large levels of conductivity at SP nine may again be linked to Wessex Way, especially as being the main road between Bournemouth and Poole it is gritted regularly during the winter.

During the third sampling session the sample points with high conductivity readings were numbers one, three and five. The highest reading was found at SP three, this is surprising

for the reasons discussed above. SP one is directly after a road so it is possible that surface water from the road was the cause. As levels were high at SP's one and three the high reading at SP five would be expected, as the high mineral content would not have been able to dilute and disperse effectively.

Within the fourth sampling run the highest levels of conductivity were found at SP's one and seven. SP one's reading could be attributed to the fact that it is directly downstream of a road. Or possibly because it is the start of the stream it may have a high concentration of surface water that does not have the chance to dilute and disperse sufficiently.

SP seven is downstream of a main road which slopes down the valley sides, there are also two discharges which look like surface water drains in the bridge just upstream of the sampling point which may contribute to the waters content.

Suspended Solids

During the first sampling session there were high levels of suspended solids at SP four and five and seven and eight. The levels at SP's four and five are likely to have entered the stream upstream of Coy Pond but downstream of the Reed beds and settling pond SUDS.

High levels of suspended solids at SP's seven and eight were probably associated as SP eight is directly downstream of SP seven. There are no specific sources of suspended solids at SP seven unless they were contained within surface run-off, drainage or caused by erosion.

On December 7th the highest concentrations of suspended solids were found at SP's three, four and seven. The readings at point three were probably linked to the works being carried out upstream, as the soil around the stream hadn't been compacted and was susceptible to erosion at that time.

The high levels of solids at SP seven again point towards the fact that there may be a problem in this area. Similarly the high reading at SP four may show there is either a problem within or upstream of the culvert feeding into Coy Pond

During the third sampling session high concentrations of suspended solids were found at SP's three and five, these are again likely to be linked to the flood basin and improvement works at the mouth of the railway culvert.

On February 19th the highest suspended solids readings were found at SP's one and seven. As no high readings had been found at SP one before, it is possible that this was a minor occurrence, caused by activity upstream or recent dry weather making particles erode easily.

The high level at SP seven again suggests that there may be a regular problem in this location, this was the third time that high levels of suspended solids were found here.

Discussion

During this section of the research project the findings from the results analysis section have been compiled to identify any sample points with regular problems. Unless there is a known source of contaminants in these areas it shows that there is a probable source of diffuse pollution.

Sample Point One

There are regular water quality problems in this area. During each sampling session there were high levels of nitrates and the water was warm. Alongside this on at least two of the sampling sessions there was high turbidity, high conductivity and higher than average pH.

Although these results do not seem to suggest that there is a constant non-point source of pollution it does seem to suggest that there are definite problems with water quality.

There are three main factors that are likely to contribute to the water quality in this area. The main one of these is the industrial/ domestic nature of the land in which the groundwater originates. It is possible that after years of polluting spills and domestic use of nitrate based fertilisers these substances have accumulated in the soil and are now contaminating the groundwater. Especially as Puckett (2004) found that nitrates have resident times within groundwater flow paths of around fifty years.

Also in this area the stream is not kept particularly clean, there are visible signs of rubbish both in and around the stream and the banks are very overgrown and may contribute pollutants. The stream is also at its smallest here being both narrow and shallow, this causes the water to flow fairly slowly and does not allow much potential for substances to disperse through the water.

Sample Point Two

Although sample point two did show water quality problems there were no determinands with problems during each sampling session. The most regular problems were a slightly

elevated temperature, this occurred on three of the two sessions and high levels of nitrates on two occasions.

The heat of the water will be caused by the effects of just emerging from the ground and the depth and flow rate as discussed for SP one. This leads to the water being stationary for longer and allows the sun to heat the water more thoroughly.

The nitrates are likely to be present from contamination of the groundwater due to the solubility of nitrates which allows them to move freely through the soil profile (MAFF, 1998). This is reinforced by the fact that the area around the stream is not treated with any nitrate based substances and there are no discharges other than the one which forms the stream.

Sample Point Three

There were three problem determinands at SP three these were high levels of conductivity, high levels of suspended solids and high levels of turbidity. This makes it look unlikely that there are any sources of diffuse pollution.

Both the turbidity and suspended solids problems can be attributed to the improvement works being carried out upstream. As mentioned within the results analysis section of this project. Due to the works there were large quantities of loose and un-compacted soil both forming the stream banks and surrounding the stream. This soil would have been easily eroded by the flowing water and any surface run-off would have also included high levels of suspended solids. The turbidity may well have been caused by the water being temporarily channelled through pipes around the works.

The high levels of conductivity are more worrying as with no main roads within the proximity of the stream there are no likely causes unless there is a problem within the culvert.

Sample Point Four

There were no important recurring problems at sample point four. High levels of suspended solids were discovered twice and the water was found to be cooler than normal twice.

The suspended solids are likely to be less of a problem in this area than any other along the stream as the solids will be able to settle out in the relatively slow flowing water of Coy Pond.

As discussed in the results analysis section the colder temperatures are due to the fact that the water is mixing with a large standing body of water, most of which is shaded leaving little chance for heating by the sun.

Sample Point Five

The main problems at this sample point are unlikely to be caused by issues in this area. As the two main problem determinands are suspended solids and high suspended solids they are more likely to be materials which have been carried down stream from SP three which have already been discussed.

However two out of the four readings did show elevated levels of nitrates. The source of this is thought to be the faeces from the duck population of Coy Pond (Personal communication, Dr Neil Smith) this should not be a problem as mixing will occur within the stream.

Sample Point Seven

The main problems at sample point seven are caused by suspended solids, high levels of nitrates and low levels of dissolved oxygen (DO). High levels of suspended solids occurred three times and problems with nitrates and DO occurred twice, both during the same sampling sessions.

The problem with nitrates and DO suggest that there is a source of organic pollution in the area which contains nitrates and consumes oxygen. There are two large surface drainage discharge pipes under the upstream bridge and a pipe with a metal accumulation around its mouth that was discharging during some sampling sessions which could be cause of the problem. It is concerning that the tunnel under the bridge is formed to create turbulence and increase the air water interface yet there is still a problem with DO. Therefore this suggests that there is a significant direct discharge downstream of the bridge.

Suspended solids in the area could either be linked to problems mentioned above or surface run-off from Prince of Wales Road which would contain particles of metals, oils and grits from the road surface and cars which use it. The flow through the bridge may also disturb sediment whilst the water is more turbulent.

Sample Point Nine

The only problems found at sample point nine were low DO, high conductivity and high turbidity. These were all recorded twice with low DO and high conductivity both recorded on the same days, however it is unlikely that they are linked.

It is most likely that the raised levels of conductivity arise from surface run-off from Wessex Way during a period of the year when gritting is regularly carried out. The cause of the lowered DO levels must be an accumulation of organic material downstream of two weirs which are present in the stream after the Wessex Way discharge to increase mixing.

The bushes either side of the stream do have branches reaching into the stream but that should not cause a problem, however as mentioned in the previous section this is a heavily vegetated area popular with dog walkers which may create more organic pollution.

The turbidity is probably caused by the weirs which have already been mentioned, but it seems strange that although the turbidity meter worked three times there were only high levels twice.

Sample Point Ten

The only problem recorded regularly at this sample point was high levels of turbidity. This was caused by a series of small weirs as the stream enters the lower gardens, also the stream bed is quite rocky through the lower gardens which may add to the turbulence as the water flows over it.

Management Options

The findings from the research carried out for this project have shown that there are some areas of the stream which require further investigation or the adoption of source control measures. Alongside the sites requiring work there are three sample points which do not require further work; these are sample points two, four and five.

Sample point one is the first sample point which requires further work, unfortunately due to space constraints around the stream options for management in this area will be limited. The main problems at this location are nitrate and conductivity levels.

The best solution would be the use of a small in-flow reed bed, allowing nitrates to be taken up and minerals which cause elevated conductivity levels to settle out or be absorbed by the plants. Unfortunately this would be costly, especially in an area of this size.

Due to the small scale, the wetland system would have to be narrow but long to improve efficiency. There would be no need for the use of front-end treatment systems such as lagoons or interceptors as recommended by Mungur et al (1996) due to the low flow speeds and small amount of flow. The majority of costs would arise from upkeep, having to crop the reeds and remove sediment build up.

The most cost effective option at sample point one would be the use of a public education campaign aimed at houses and businesses in the area, highlighting the effects of any nitrate based fertilisers which may be used and the effects of pouring substances into soil. This could prove to be both cheap and effective.

A similar campaign has already been used by the Bourne Stream Partnership educating local people to think about what they pour down drains. This was called the Yellow Fish Campaign and included the painting of yellow fish beside kerbside drains to make people think about where substances go. A similar campaign aimed at groundwater and the in right locations should also work.

It would also be worthwhile to carry out a clean-up around the start of the stream at this point, cutting back vegetation and clearing away rubbish this would both remove any polluting effects and make the stream more visible, reminding the local population that it exists.

Although there were high suspended solid contents at sample point three these were attributed to the works being carried out. Therefore the problem at this point was the high conductivity levels. The settling area which was created may solve this problem but further study may be required to find out. It would also be useful to sample at the upstream and downstream mouth of the railway culvert to identify whether the source of the conducting minerals is from within the culvert.

At sample point seven, further studies need to be carried out to find the source of discharges from the pipe on the west side of the stream after the Prince of Wales road bridge. This was discharging high levels of nitrates both times and low levels of DO were found.

If no problems are found to be emanating directly from this input, then there is a definite problem with low levels of dissolved oxygen which needs further investigation. This is a highly vegetated area which could be a cause, but if left unchecked eutrophication could start to become prevalent in the slower moving areas as nitrates build up and the amount of dissolved oxygen decreases.

The best methods of control at sample point nine would be the use of either filter drains along the sides of Wessex Way or the channelling of surface water drains through a filter strip before reaching the stream (SEPA, 1999).

Unfortunately filter drains would be inappropriate along the actual road bridge but used either side of the bridge they would prove to be effective. There is also space around the stream in this area to fit filter strips of at least the 5 metre minimum effective width (Environment Agency, 2002).

The use of both of these methods together would be even better, slowing the flow of dirty water to the stream and providing two areas where pollutants can be absorbed by the soil or

deposited from the water. Both methods would reduce the mineral content of the water which causes conductivity to occur. The filtering of the dirty water may also increase the dissolved oxygen content as the water quality improves and any excess organic solids are removed.

Another possible method to improve the oxygen content of the water may be to increase the size of the small weirs. This would increase turbulence and the eroding effects but would also allow more oxygen to mix with the water. However it would be worthwhile to conduct another survey into this stretch of the stream to confirm that there is no specific discharge causing the lack of oxygen.

Conclusion

The investigation for non-point sources of pollution within the Bourne Stream has had some success, three locations have been identified as having water quality problems and one more has been recommended for further study.

Unfortunately due to the unreliability of some of the sampling equipment, results could not be obtained for each parameter during every sampling session. More reliable equipment may have further helped to identify problems. It would also have been beneficial to sample on more occasions and on a more regular basis as, if issues are based on misconnections then they may not be apparent every weekend and some problems could be more prevalent on week days.

It was apparent that some locations have regular problems that could be dealt with using sustainable urban drainage systems and the use of these techniques would help to improve water quality. However further sampling may be useful for any project entailing large costs. More in depth sampling would also ascertain that these are regular problems and not based on single events such as substances being poured down drains or over use of fertilisers or weed killers around the stream. As conductivity was a regular problem in some areas further sampling programmes in the summer may show that levels drop as gritting of roads is reduced during the summer period.

No problems likely to cause failure of any relevant legislation were found but accumulations of substances may increase the chance of failure. In retrospect the use of biological sampling methods along the stream would have added to the chemical sampling results, aiding the discovery of diffuse pollution sources, as regular inputs would cause biological life to deteriorate. This would be more obvious as chemical sampling only provides a snap-shot in time.

It is obvious from the study of both the results from this project and Bournemouth beaches failure to meet the EC guideline standards that there are definite problems. The best solution would be to increase the length of the outfall to create a long sea outfall for the stream to use on a regular basis. This would allow for the stream water to dilute and

disperse more effectively and reduce the chance of contaminants being washed back towards the beach. But this would be an expensive scheme just for the purpose of discharging the stream water more effectively and is unlikely to be put into place.

To conclude this project has been partly successful in pin-pointing areas of possible diffuse pollution and suggesting relevant management methods. The results would have been strengthened by the use of biological sampling alongside chemical sampling with both of these being carried out on a more regular basis. This research has definitely identified areas of the stream requiring further study and if the funding is available the works suggested should prove to be effective in improving the overall water quality of the stream.

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