Assessing the impact of Ashlands Waste Water Treatment Plant on the microbiological quality of the River Wharfe in Ilkley, West Yorkshire

An interim Report, July 2019

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Summary

After three months of citizen scientists monitoring coliform bacteria concentrations upstream and downstream of Ashlands WWTP in both high and low flow conditions it is possible to make several conclusions:

- **public health risks are high in both low and high flows downstream of the outfall e.g. at Beanlands Island;**
- **they are relatively low in dry, low flow conditions upstream of the outfall e.g. above the Iron Bridge; but**
- **relatively high in high flow conditions upstream of the outfall;**

The threat below the outfall is from both the Ashlands treated effluent and the storm overflow. The public should be advised not to swim downstream of the Iron Bridge. The threat above the outfall in high flow conditions is from unknown sources upstream of the town. More work is required to identify these sources and to assess how coliform concentrations in the river vary with riverflow and other environmental factors before further guidance on bathing safety at the lido beach can be given.

Introduction

Untreated waste water is frequently discharged into the Wharfe from the the Ashlands WWTP in Ilkley causing severe localised water pollution and threats to the health of people downstream using the river for amenity and recreation.

The Environment Agency (EA) is monitoring ammonia concentrations and biochemical oxygen demand (BOD) at Denton Bridge but neither Yorkshire Water (YW), who are responsible for the discharges, nor the EA, who are responsible for protecting water quality, monitor coliform bacteria concentrations, yet these are the organisms most likely to give rise to public health concerns.

In the absence of such data, the Ilkley Clean River Group (ICRG) have initiated a coliform bacteria monitoring programme using volunteers to collect samples. Samples are sent for analysis to ALS Ltd, an accredited microbiological laboratory based in Coventry.

The overall objective of the project is to assess the level of health risk that citizens using the river are exposed to following storm-related discharges of untreated sewage. Here we outline the project design, describe methods of sample collection and analysis, present preliminary results after three months of sampling and make recommendations for future work.

Project Design

The project is planned to run for 12 months in order to take in seasonal changes in factors such as river flow, temperature and use of the river by people. The project has six initial objectives:

1. **Coliform concentrations during dry weather flow**. A set of baseline or control samples taken in dry weather to establish coliform concentrations when only treated effluents are being discharged into the river. Sample sites are the Old Bridge (Figure 1, Site 0), close to the Lido immediately upstream of Ashlands (site 1), between the storm outfall and the treated outfall (site 2), close to the beach at Beanlands Island (site 3) and at Denton Bridge (site 4). The EA monitors water quality for EU Water Framework Directive purposes at Denton Bridge.
2. **Seasonal changes in coliform concentrations**. Monthly samples collected from the Denton Bridge site to assess the extent to which coliform concentrations change on a seasonal basis.
3. **Comparisons between indicators of untreated sewage**. To take advantage of the EA's decision to monitor water quality at Denton Bridge coliform samples taken at that site on the same day as the EA. The objective is to make direct comparisons between the results for BOD and ammonia with those for coliforms to assess whether BOD and/or ammonia measurements can be used as a proxy for coliforms in future.
4. **The impact of storm overflow events on coliform concentrations**. Samples taken opportunistically during storm overflow events. The objective is to assess the impact of overflows on coliform concentrations for different seasons and different river flows. For each event samples are being taken at sites as described in (1) above.
5. **Coliforms from the river bed**. In response to a suggestion from the Rivers Trust sample water after deliberately stirring the bed of the river at sites 2 and 3 (Figure 1). Data from New Zealand have indicated that paddling by bathers may resuspend bed sediments into the water column and thereby increase risk of public exposure to coliforms.
6. **Testing citizen science coliform kits.** The Rivers Trust are eager to develop inexpensive but accurate coliform test kits for use by citizen scientists. We have agreed to test LaMotte kits by comparing the results from them with the results from our samples taken at the same time.

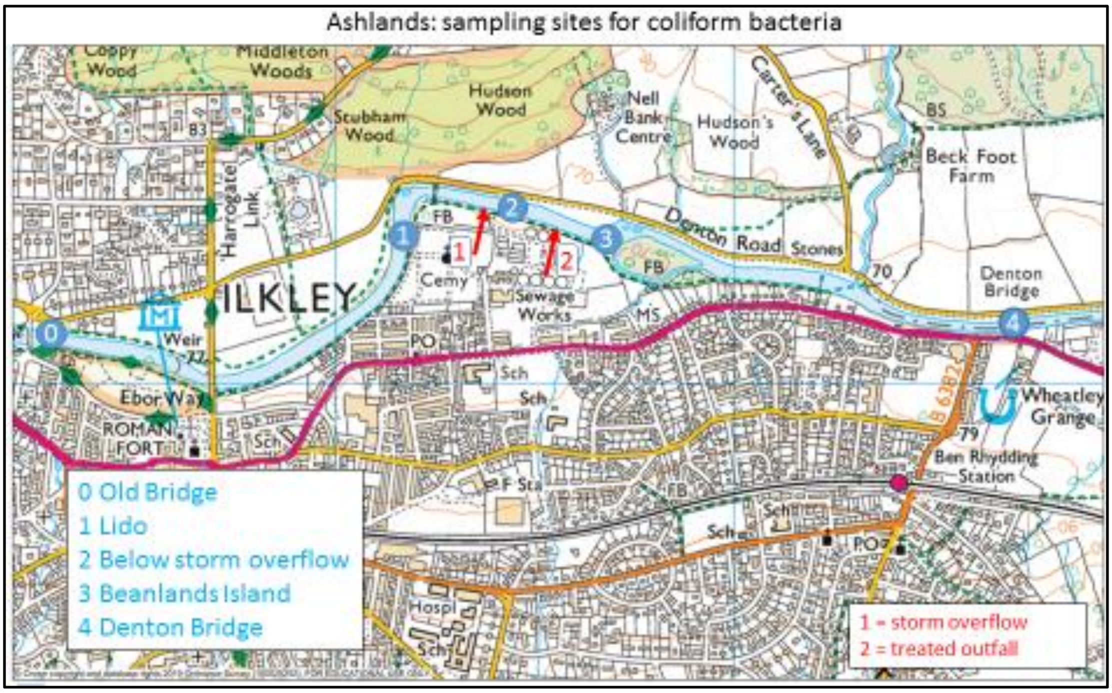

Figure 1. Map of sampling sites on the River Wharfe upstream and downstream of Ashlands Waste Water Treatment Plant.

Methodology: Field sampling

1. A grant from the Rivers Trust enabled us to buy a portable fridge and assemble other items of equipment required to carry out field sampling. Equipment includes:

   - portable fridge powered by car battery and kept at between 2 and 8 degrees C;
   - pre-chilled cool bag;
   - sufficient sample bottles as provided by ALS, including spares;
   - bottle pre-filled with sterile tap water to act as a blank (marked B with date);
   - rope with throw bottle and lead weight for sampling in high flow;
   - safety harness and rope;
   - disposable gloves;
   - marker pens;
   - notebook and camera;
   - LaMotte test kits.

2. The sampling team has a minimum of three members, one to take the samples, one to observe the sampling process and where necessary be responsible for the sampler's safety, and one to be responsible for equipment and to take notes and photographs.

3. Two sterile sample bottles as provided by ALS are needed for each site labelled with Site code (Ashland 0, 1, 2, 3 or 4), date (day, month, year) and whether a primary (P) sample or duplicate (D) sample.



4. The samplers are very experienced local anglers equipped with chest waders. Rope and safety harnesses are available. Except when explicitly required (see objective 5 above) care is taken not to disturb the river-bed. Any disturbance caused is allowed to clear downstream before sampling.

5. As far as possible deep-water mid-flow samples 15 cm below the water surface are taken. The sampler faces upstream, inverts the sterile sample bottle provided by ALS, lowers it into place and then rotates the neck into the flow.

6. An air gap in the neck of the bottle is left to allow the sample to be mixed in the lab before emptying.

7. The second (duplicate) sample (marked D) is taken from the same location after a wait of two minutes.

8. The samples (including blank when appropriate) are placed into a cool bag immediately after sampling and returned to the portable fridge.

9. The samples are kept refrigerated in the dark en route to the pick-up depot in Wakefield for analysis in the Coventry ALS lab within 24 hours of sampling.

<u>Methodology: Laboratory analysis (ALS Ltd)</u>

A known volume of water sample is filtered through a membrane filter with 0.45 µm pores to trap bacteria. The filter is then placed on a selective growth medium m-Lactose Glucoronide Agar which contains lactose, phenol red as an indicator of acidity and the chromogenic substrate 5-bromo-4-chloro-3-indolyl-β-D-glucuronide (BCIG) to indicate the production of β-glucuronidase. Plates are incubated at 30°C for 4 hours and at 37°C for a further 14 hours after which colonies characteristic of coliforms and *Escherichia coli* are counted and picked off for confirmation where necessary.

Presumptive total coliforms (TC) appear as yellow, green or blue colonies. Presumptive *Escherichia coli* appear as green colonies. Confirmed total coliforms express β-galactosidase and are oxidase-negative. Confirmed *Escherichia coli* express β-galactosidase, β –glucoronidase and are oxidase negative. Confirmation is performed using either protein profiling, or defined substrate technology.

<u>Results</u>

The project is designed to run for 12 months. Here we present results from the project starting in April 2019 to the middle of July. The data include results from the start-up trial and from samples taken during high flow and low flow.

1. **Trial sampling on the 29^{th} April**

The methodology was trialled on the 29^{th} April during low flow conditions with samples taken at sites 1, 2, 3 and 4. Only total coliforms were monitored. The results showed low numbers at sites 1 and 2 upstream of the treated effluent outfall but high numbers at sites 3 and 4, downstream. The high numbers were higher than expected by the ALS laboratory with values expressed as >10,000 cfu/100 ml indicating that future samples would need to be diluted further to enable accurate values to be obtained.

2. **Samples taken on 13^{th} June (high flow)**

On the 13^{th} June the river was running high and a storm water spill was occurring from the Ashlands plant at the time of sampling. Samples were taken at all sites as described above except a third sample was taken from the Old Bridge site to test the use of a throw bottle from the bridge parapet and a sample was taken from the effluent outfall itself (Figure 2). Samples were analysed for *E. coli* as well as TC but only *E. coli* data are shown in Figure 3.

Figure 2: Treated effluent outfall

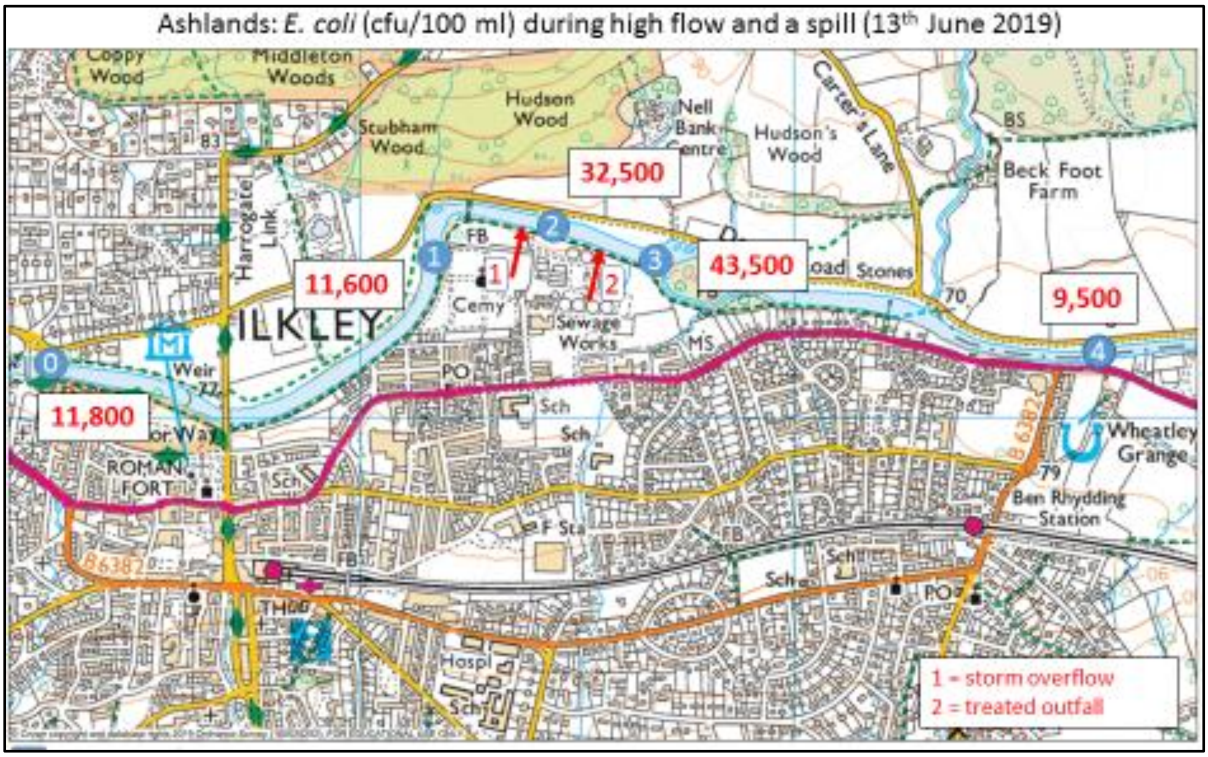

Figure 3. E. coli data for sampling sites upstream and downstream of Ashlands on 13th June 2019.

Key points are:

1. Values are high at every sample site.

2. The two sites upstream (0 and 1) both have high values (NB as a guide 900 cfu/100 ml is the highest permitted for bathing water status) although not as high as site 2 and 3 close to the outfalls. These values indicate that in high flow there are significant sources of *E.coli* upstream either from small sewage works and/or from agricultural land.

3. The sample at site 2 just downstream from the storm overflow shows a three-fold increase in concentration reflecting the additional input of untreated effluent at this point.

4. The sample at site 3 (Beanlands) has the highest concentration reflecting the further input of *E. coli* from the treated effluent outfall. A sample from the treated effluent outfall itself gave a value of 43,000 cfu/100 ml (data not shown on Figure 3). This finding is very significant as it indicates that the main coliform bacterial contamination of the river comes from the treated effluent not from the storm overflow.

5. Concentrations at Denton Bridge (site 4) are significantly lower than at Beanlands Island (site 3). This is a surprising finding, but confirmed by the 10th July results (see below). The decrease may be due to a real die-off between the two sites and/or due to a delay in the bacteria from close to the outfall being completely mixed into the water column at the sample point.

6. The LaMotte test kits reacted positively at all sites, showing the presence of coliform bacteria at all sites but not indicating differences in abundance between sites and samples (Figure 4).

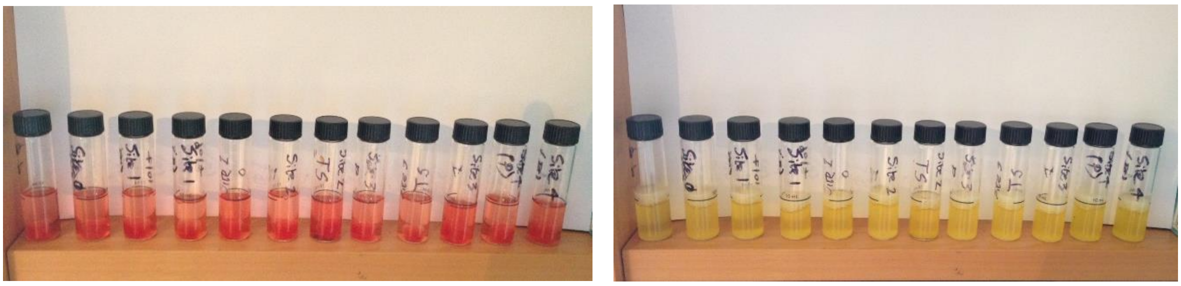

Figure 4. LaMotte coliform test kits: just after sampling and two days later

3. Samples taken on 10th July (low flow)

The 10th of July samples followed a long period of dry weather and river flows were very low. Only treated effluent was being discharged from Ashlands. The conditions were therefore substantially different from those on 13th June providing an excellent opportunity to compare bacterial populations in both high and low flows. Again both TC and *E.coli* concentrations were monitored, but only *E.coli* data are shown on the map (figure 5). The sampling strategy was very similar to that of the 10th June except two additional samples were taken to assess the impact of resuspending sediment from the river bed on coliform numbers (see objective 5, above).

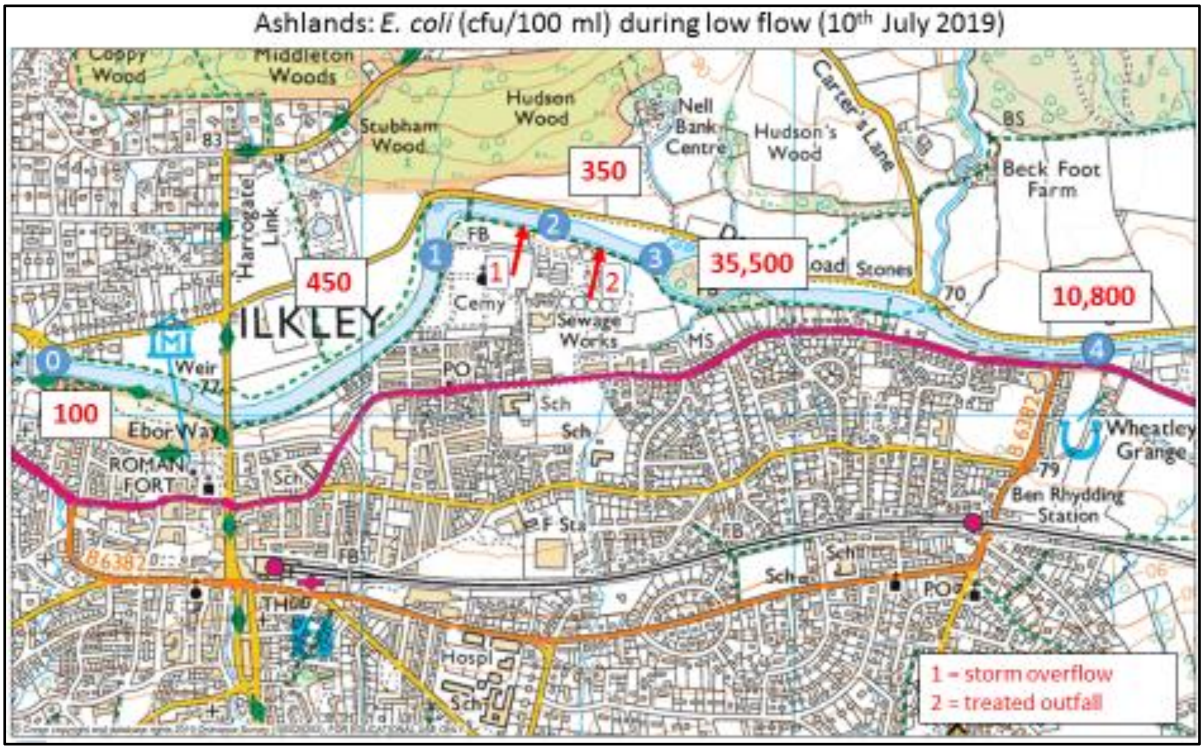

Figure 5. E. coli data for sampling sites upstream and downstream of Ashlands on 10th Julyh 2019

Key points are:

1. The values upstream of Ashlands at sites 0 and 1 are low and within the *E.coli* limits for Bathing Waters. These values concur with those found on the 29th April in equally low flow conditions, and indicate that the risk to the public using the beach and the river for recreational purposes upstream of the outfall in these conditions is low.

2. Values are equally low at site 2 downstream of the storm overflow. This shows the absence of any stormwater spilling into the river above this sample point and also indicates that the river, at these flows, is not resuspending and entraining bacteria-rich sediments from the bed of the river, although such sediments derived from previous storm overflow events occur at this point.

3. The additional samples taken at sites 2 and 3 after the river bed was disturbed by trampling (to simulate the action of someone paddling in the water) showed no significant difference in *E.coli* concentration from the undisturbed samples indicating that this form of recreation is unlikely to increase exposure to coliform bacteria.
4. At site 3 concentrations are very high, the same order of magnitude as for high flow conditions on the 13th June. It is clear that these values reflect the high concentrations being discharged from the treated effluent outfall and their relative lack of dilution by the river flow.

5. The Denton Bridge values are much lower than upstream values below the outfall but very much higher than upstream at sites 0, 1 and 2. The three-fold reduction in values is similar to the reduction between sites 3 and 4 in high flows (Figure 2) indicating the need to assess concentrations with distance downstream.

6. As for the high flow samples above the LaMotte test kits reacted positively at all sites but did not indicate any difference between sites and samples.

Conclusions

Although the project has only been running for three months some very clear patterns are emerging. Some of the initial questions outlined above have been answered. Other results point to the need to redefine some of our objectives. Conclusions at this early stage are as follows:

- The field and laboratory methods adopted appear robust. Samples taken from the bankside or from bridge parapets give similar values, primary and duplicate samples generate comparable results. A blank sample included in the trial survey was shown to contain no coliform bacteria;
- Sites 0 and 1 show very similar results at both high and low flows suggesting that one of those sites is now unnecessary;
- As there is a strong (but not perfect) relationship between TC concentrations and *E. coli* concentrations in both high and low flow conditions it is unnecessary to continue to monitor both populations. *E.coli* is more closely related to human sources of bacteria and is one of the measures used in determining Bathing Water status, so this is the measure that should be continued, see below;
- The “trample samples” showed no enhancement in numbers. However, **there is a large patch of organic-rich sediment on the river bed close to the storm-water outfall. This sediment is likely to be resuspended in high flows and carried downstream.** Samples should be analysed and the extent of the patch mapped at some point in the future;
- The main source of coliforms downstream is the treated effluent not the occasional storm spills. There is therefore less need to continue sampling at Denton Bridge at the same time as the EA as this exercise was designed to assess whether spills could be detected using BOD and ammonia as well as to explore the relationship between coliform concentration and river discharge. We can see now that that these potential relationships are confounded by the continuous discharge of bacteria from the treated outfall;

- **The observation that the treated effluent has a very high *E. coli* concentration indicates that contamination downstream will always be high and not just related to spill frequency.** This also indicates that there is less need to capture the impact of multiple spills at different flow regimes as described in objective 4 above. It is important, however, to capture the impact of at least one overflow event occurring at low flows;
- Coliform concentrations decrease downstream quite rapidly in both high and low flow conditions, indicating the **need to understand the rate of downstream die-off**. For example, how low do the numbers become before the next injection of coliforms at Ben Rydding and beyond? What is the threat from Ashlands to the general public downstream in Burley and Otley?
- **The finding that the treated effluent outfall is the major source of coliforms shows that there is a threat to the public at all times at the Beanlands site and elsewhere below the outfall. The threat is not just related to the intermittent spills from the storm overflow, it is a continuous threat. A warning to the public at this point on the river is necessary;**
- High values of coliforms in the treated outflow also point to an additional weakness in the functioning of Ashlands that has not hitherto been discussed. Could measures be introduced to disinfect the treated effluent e.g. by U-V light?
- The relatively low concentrations upstream of Ashlands in dry weather suggests **there is some merit in pursuing bathing water status for the main recreational area upstream of the Iron Bridge**. As such it would make sense not only to continue monitoring *E. coli* populations but to add a protocol for measuring enterococcal bacteria as required by the Bathing Water Directive;

Figure 6: Bathing beach near the Iron Bridge

- Given more data on both *E. coli* and Enterococci in relation to river flow over coming months it may be possible to provide the public with some reassurance about the safety of using the river e.g. under specified low flow conditions;
- **The relatively high concentrations of TC and *E. coli* in high flow conditions give greater cause for concern posing serious questions about the upstream sources of coliforms**. But arguably if such sources could be identified and controlled then acquiring Bathing Water status in future might just be conceivable;
- If this remains an objective it will be necessary to examine all potential sources of coliforms upstream starting with the small sewage treatment works that serve communities like Grassington and Kettlewell;
- Farm animals may also be an important source of coliform bacteria. Controlling the access of farm animals to water-courses is already a key EA objective in attempts to reduce diffuse nutrient pollution. Such land management would also have benefits in reducing contamination by bacteria;
- The LaMotte kits indicate the presence of coliform bacteria but have little value for this kind of study where accurate values for bacterial abundance are more important than presence/absence.

Recommendations

This is a good time to review progress being made in the project to assess the extent to which the present schedule of monitoring needs to be modified and the extent to which some resources need to be re-directed and/or additional funding sought based on the data so far. Recommendations are:

- **As a priority to sample at least once more at the sites described above for *E. coli* to capture the impact of a spill on the river when flow is low;**
- To discontinue routine co-sampling at Denton Bridge with the EA;
- To discontinue monitoring for TC concentrations but retain *E.coli* monitoring as there is a relatively close relationship between TC and *E.coli* and *E.coli* measurements are more informative;
- To discontinue monitoring at the Old Bridge (site 0) as values there are very similar to those at the Lido (site 1);
- To discontinue using the LaMotte kits;
- **If resources allow to start monitoring for *Enterococcus* spp. as well as *E. coli* following the protocol for the EU Bathing Water Directive across a range of flow conditions. This would enable a relationship between bacterial contamination and river flow to be established potentially allowing days when conditions were safe for swimming to be predicted;**
- **To design and cost a project to enable upstream sources of coliform bacteria to be established.** If additional funding could be obtained this could include co-sampling for diatoms, invertebrates and nutrient chemistry. A pilot project could be designed to compare *E. coli* concentrations upstream and downstream of one selected sewage works and upstream and downstream of one selected stream inflow;
- **To sample river water downstream for *E. coli* and Enterococci as far as Otley** to establish the potential impact of Ashlands WWTP coliforms on local communities down the river;
- **To advise Ilkley Town Council to warn the public that river water downstream of the Iron Bridge is unsafe in all flow conditions**;

- **To ask Yorkshire Water whether measures can be taken to disinfect their treated effluent at Ashlands.**

Acknowledgements

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