A study of the benthic macroinvertebrate composition of the Kings River and its major tributaries to determine the water quality of the catchment.

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Commissioned by the Nore Suir River Trust Ltd

July 2010

Introduction.

The Kings River like its main tributary, the Munster River rises in the Slieveardagh Hill in Co. Tipperary and flows east through Callan in Co. Kilkenny to join the Nore northwest of Thomastown. This river is one of the main tributaries of the River Nore, it is approximately 12km long packed full of little weirs and rapids. The river is narrow in nature and can be quiet fast flowing. The Kings River is a rich Limestone River something like the rich chalk streams that can be found in England. The river can be as wide as 15-20 yards in places with a gravel bottom and occasional 'shallow holes'. There is a lot of nice streamy water, especially early in the season and some of the best trout fishing can be had from April to June. In previous years the brown trout average in the river was about ¾lIb, with trout to 3-4 lb often taken (O' Reilly 1991). However in recent years the local anglers of the river report that trout are now much smaller with the average trout weighing ½ Ib with an occasional trout over a 1 lb weight caught. Wet fly fishing is the most popular from March to May and there can be good evening dry-fly fishing in summer. Fly hatches include various olives, mayflies, black gnats, midges and various sedges.

It is now well recognized that this river has the potential to be one of the main spawning streams for Atlantic salmon (*Salmo salar*) on the River Nore catchment. One of the main limiting factors of the Kings River catchment in terms of producing juvenile salmon in previous years were barriers in the form of weirs preventing the upstream migration of Atlantic salmon. However in the autumn of 2009 two new fish passes (rock ramp passes) were constructed on the two major weirs of the catchment (Boland's and Bradley's weirs). Now since most of the catchment has been made accessible to migrating salmon, other major problems such as organic pollution must be addressed as a priority as the conservation status of Nore Atlantic Salmon is at a critical level.

One of the most practical methods to determine the health of an aquatic ecosystem and to investigate the impact of organic pollution (sewage outfall, agricultural run-off) on water quality is to analysis the benthic macroinvertebrate composition of a particular site. Various biological water quality indices have been developed to relate the composition of benthic invertebrates and actual water quality. In Ireland the Environmental Protection Agency have developed a water quality index known as the Q-Scheme, which now regularly used to monitor the quality of surface waters under the Water Framework Directive. The

Environmental Agency in England has also developed an index like the Q-Scheme known as the BMWP score or Biological Monitoring Working Party index. In relation to the Q-Scheme different families of insect are classified according to their perceived thresholds towards levels of dissolved oxygen which organic pollution will have an adverse effect on concentrations of dissolved oxygen. Some orders of insect such as the Order Plecoptera (Stoneflies) require high levels of dissolved oxygen and are only found in such areas whereas other families of insect are very tolerant towards low levels of dissolved oxygen such as Family Chironomidae (blood worms) or the Class Hirudinea (leeches). A build up of such tolerant invertebrates would indicate that a particular aquatic ecosystem is polluted due to organic pollution. With regards to Q-Scheme groupings there are five different classifications according to tolerance thresholds towards levels of dissolved oxygen. Group A insects are most sensitive and include most families of the Order Plecoptera (Stoneflies), one Family of the Order Ephemeroptera (Mayflies) and one family of the Order Trichoptera (Caddisfly). Group B are less sensitive and comprises some families of stonefly, mayfly, most cased caddis and the Order Odonata which are dragonflies. Group C insects are tolerant towards low levels of dissolved oxygen and include the phylum Tricladia (flatworms), the freshwater shrimp (*Gammarus duebeni* and *G. pulex*), all caseless caddis, all beetle larvae and adults (Coleoptera), Simuliidae, which are black fly larvae and Hemiptera, which are the water-boatmen. Group D insects are very tolerant and include the Class Hirudinea (leeches), Phylum Mollusca, which are various species of snail, *Asellus spp*., and lastly Group E comprise the most tolerant group of insects including Tubificidae and *Chironomus* which is the blood worm. The BMWP index is based on a similar system where each family of insect is allocated a score out of 10. Scores are given for the presence of each key family group, which are then added together. Individual scores range from 1 (organic pollution tolerant) to 10 (intolerant). They are many advantages of community level indicators such as the Q-Scheme and BMWP score. They can provide a valuable perspective with regard to the biological magnitude of changes and the community response is significant because it reflects changes for multiple species, whereas indicator species responses involve only one species. Chemical analysis is specific to particular pollutants which may not highlight other stress factors which can be monitored through the presence, absence and abundance of benthic invertebrates.

Due to the recent developments on the Kings River in terms of opening up the catchment to migrating salmonidae species and lamprey eel, this now means that the ecosystem can produce much more juvenile salmonidae species as much of the fluvial area of the catchment is now assessable. Since much of this work is done, the next task is to ensure that juvenile salmonidae fish species have a clean habitat to develop in. The aim of this current project was to determine the water quality of the Kings catchment including the major tributaries through analysing the benthic macroinvertebrate composition at various sites. Also a primary aim of the project was to determine the effect if any the wastewater treatment plants (Callan and Kells) are having on the Kings ecosystem.

Method.

Sample Area.

The sample programme entailed concentrating efforts below the major wastewater treatment plants on the Kings River (Callan and Kells). Also samples were taken above these locations to get a direct comparison of water quality in aid of determining the effect of these plants. In total 11 invertebrate samples were taken from various locations across the Kings catchment. In terms of tributaries sampled, the Munster River was sampled and a small tributary of this river was sampled (termed Munster 2). These two smaller rivers comprise the largest tributary of the catchment which joins the Kings River just below Ballyline cross. The other major tributary of the Kings, the Glory River was sampled just above Kells village where it meets the Kings River. The last tributary that was sampled was the Black Stick River (Bata Dubh) which joins the Kings River at Ennisnag. In terms of invertebrate samples taken on the Kings River, 5 samples were taken below Callan. These included directly below Callan treatment plant, Newtown which is about 2km below the plant, samples were taken at the two major weirs (Boland's and Bradley's) and lastly one sample was taken from the lower Kings at Ennisnag. Two samples were taken above the treatment plants, which included a sample about 1km above Callan town and a sample was taken from the upper Kings in Co. Tipperary.

Macroinvertebrate Collection.

The sample collection was carried out by the kick sample method. This was done in accordance to the method carried out by the Environmental Agency in England. A three minute kick sample was carried out at each site which entailed sampling the various habitats

found at each site relative to their proportion. Sampling was carried out in this way to get a good representation of the macroinvertebrate community present at each sample area (Murray – Bligh, 1997). Examples of different types of habitat included slow flows, riffles, shaded areas, stony substrate, and sandy substrate

While carrying out the sampling, the net was held vertically on the river bed against the current. While doing this, the substrate just above the net was disturbed by moving ones foot and heel side to side. By carrying out this process, macroinvertebrates are dislodged from the substrate, some of which are captured in the net.

After the kick sampling was carried out, some of the larger stones and rocks were removed from the substrate for a 1 minute period. This was done in case any different communities were present at the sites that might not be dislodged by the kick sampling.

2.3 Sample treatment for identification

Upon returning to the laboratory the excess water in the sample buckets was drained off using a 0.5 mm sieve and were immediately fixed using 100% industrial methylated sprits (IMS). The contents of each bucket were then transferred into white trays and with the aid of bench lamps to improve lighting; the macroinvertebrates were separated from the river debris using forceps, cut-off pastuer pipettes and plastic spoons.

Once the macroinvertebrates were separated in each sample, they were identified down to family level to calculate the various water quality indices such as BMWP and the Q-Scheme. To identify the macroinvertebrates they were placed into a petri-dish with distilled water and examined under a stereoscopic microscope using various magnifications ranging from X10-40. Macroinvertebrates were identified using various Freshwater Biological Association keys such as Edington & Hildrew, (2006), Elliott & Mann, (1998), Eillott, (1988), Gledhill et al, (1993), Hynes, (1993), Macan, (1994), and Wallace et al, (2003).

Results

3.1 Macroinvertebrate collection and Calculation of Biotic indexes.

From the 11 samples taken throughout the Kings catchment a great variety of insects were found, however there was nearly a complete absence of the Order Plecoptera (Stoneflies) with the exception of the Munster and Glory Rivers and the upper Kings. From the samples, 6 orders of insect were recorded, the orders Plecoptera, Ephemeroptera, Trichoptera, Diptera

Coleoptera and Amphipoda. As well as these orders of insect other groups of invertebrates recorded included the Class Hirudinea, Phylum Mollusca and Class Oligochaeta. To analyse the abundance of different orders of insect over the whole catchment, the most abundant groups included the Order Ephemeroptera where the families Ephemerellidae and Baetidae were the most abundant. In terms of the most abundant Caddisfly (Order Trichoptera) throughout the catchment, the families Rhyacophilidae, Hydropsychidae, and Limnephilidae were present in high numbers at most sites. Adult beetles and larvae (Order Coleoptera) were also strongly present at most sites with the families Elminthidae, Dytiscidae and Gyrinidae the most abundant. Diptera larvae were recorded at every site with the families Chironomidae, Simuliidae, and Dicranata the most abundant. On a more worrying note the Class Hirudinea were recorded at nearly every site with the exception of the Munster River, Munster 2 and above Callan on the Kings River. It is well known that leeches are external parasites of fish. When numbers reach high abundances mortalities will result as they can break down the soft tissue of the gills. In summary a total of 28 families of invertebrate were recorded throughout the catchment. Specific groups of insect found at each site will be discussed in the discussion section with reference to each water quality result.

From table 1, the water quality indices for each site can be seen. Within the table the Q-Scheme ratings as well as the BMWP and ASPT scores can be seen. BMWP scores ranged from 109.6 recorded below Ennisnag on the Kings River to 42 which was recorded at Newtown on the Kings. ASPT scores recorded ranged from 7.6 (Munster River) to 4.7 (Newtown). Q-Scheme ratings ranged from Q2-Q3 (Moderately polluted) recorded at 4 sites on the Kings and 1 site on the Black Stick River and the other Q-Scheme rating recorded was Q3-Q4 (Slightly polluted) which was recorded at 3 sites on the Kings and the Munster and Glory tributaries.

Table 1. Table to represent water quality recorded at the various locations across the Kings catchment according to Q-Scheme and BMWP Scores.

River/Location	Q-Scheme rating	Water Quality (Q-Scheme)	BMWP Score	ASPT	Water Quality (BMWP Index)
Sample Above Callan treatment plant.	Q3-Q4. Slightly Polluted	Class B water quality	62	5.6	Moderate Quality

Table 1. Table to represent water quality recorded at the various locations across the Kings catchment according to Q-Scheme and BMWP Scores.

River/ Location	Q-Scheme rating	Water quality (Q-Scheme)	BMWP Score	ASPT	Water quality (BMWP Score)
Sample below Callan treatment plant. Kings River	Q2-Q3. Moderately Polluted	Class C water quality	50	5	Poor water quality
Sample taken at Newtown on the Kings River	Q2-Q3. Moderately Polluted	Class C water quality	42	4.7	Poor water quality
Sample taken at Boland's Weir on the Kings River	Q2-Q3. Moderately Polluted	Class C water quality	92	6.1	Moderate Quality
Sample taken at Bradley's weir on the Kings River	Q2-Q3. Moderately Polluted	Class C water quality	79.3	6.6	Moderate Quality
Sample taken from below Ennisnag on the Kings River	Q3-Q4. Slightly Polluted	Class B water quality	109.6	6.9	Moderate to Good water quality
Sample taken from the upper Kings	Q3-Q4. Slightly Polluted	Class B water quality	82.7	7.2	Good water quality
Sample taken from main Munster River	Q4. Slightly Polluted	Class B water quality	79.61	7.6	Good water quality
Sample taken from Munster River (2)	Q4. Slightly Polluted	Class B water quality	89.9	6.4	Moderate water quality
Sample taken from the Glory	Q3-Q4. Slightly Polluted	Class B water quality	90.7	7.4	Good water quality
Sample taken from the Black stick River	Q2-Q3. Moderately Polluted	Class C water quality	92.9	6.2	Moderate water quality

Discussion

As can be seen from the results of the report, the aims of the project which were outlined in the introduction were successfully achieved; however the results do not indicate that the Kings River is a healthy aquatic ecosystem. The results are not all bad news in that the major tributaries to the Kings are only slightly polluted and according to the BMWP index have good quality water. With regards to particular tributaries, the main Munster River has good quality water and Munster 2 has moderate quality water and according to the Q-Scheme is only slightly polluted. Visual observations of these two rivers on the day of sampling noted that there was very little excess eutrophication. This was due to minimum algae growth at the sites and normal aquatic oxygen producing plants were present and flowering. In terms of the invertebrate composition found at these sites, the Order Plecoptera, Family Perlidae was found in the main Munster River as well Family Heptageniidae which is an oxygen sensitive mayfly. Other abundant invertebrates found at this site included Family Ephemerellidae which is a mayfly, Family Simuliidae and Family Chironomidae which are true flies and Family Gammaridae which is the freshwater shrimp. With respect to the Munster 2 system, Family Ephemerellidae was super abundant, Family Gammaridae was abundant, Family Limnephilidae which is a caddisfly was abundant, and a high diversity of the Order Coleoptera was recorded with 4 different families. In terms of true indicators of dissolved oxygen levels the Family Heptageniidae was recorded in the Munster 2 system however they were rare and no stoneflies were noted.

In terms of the Glory River, according to the biological water quality indices calculated in this report, this River is slightly polluted according to the Q-Scheme and has good quality water according to the BMWP scores. Again visual observations of the benthos indicate that eutrophication was under control in this river as excess algae growth was absent. In terms of insect life found in this river, the Order Plecoptera, Family Perlidae was recorded, Family Heptageniidae was found, the Families Hydropsychidae and Rhyacophilidae which are caddisfly were super abundant, Family Simuliidae was super abundant and family Gammaridae was abundant. The only family of the Class Hirudinea recorded was Family Piscicolidae which was rare. Out of all the Families of leech found in the British Isles, this family requires the highest dissolved oxygen levels.

Out of all the tributaries sampled from the Kings catchment, the Black Stick River was the only one that was moderately polluted with moderate water quality. Even before a kick

sample was taken, excess eutrophication was evident from the thick algae growth on the bottom and there was a complete absence of the usual species of aquatic plant. While sampling this river a few different locations had to be examined before an appropriate site was found to take the kick sample. This was due to the amount of slit on the bottom as well as the excess algae growth. This is a small tributary of the Kings and because there is no sewage treatment plants on this river, organic pollution is most probably coming from agricultural run-off, however this is not definite because no evidence of this was observed. In terms of aquatic invertebrates found at this site, the Family Chironomidae was super abundant, Family Glossiphoniidae which is a leech was moderately present, Family Gammaridae was super abundant, Family Ephemerellidae was super abundant and 4 different families of caddis were recorded, Hydropsychidae, Rhyacophilidae, Limnephilidae, and Family Polycentropidae. Also other indicators of low levels of dissolved oxygen included Family Pulmonata which is an aquatic snail and the Class Oligochaeta which are aquatic worms.

As you can seen from the results discussed above some rivers in the Kings catchment are nearly meeting their targets with respect to the Water Framework Directive which requires all surface waters to at least have “good status by 2015”. However this is not the case for the Kings River itself below Callan town. A few interesting results became apparent while carrying out this project. Just above Callan town, the Q-Scheme index indicated that this site was slightly polluted and according to the BMWP index this site has moderate water quality. The sample taken from the upper kings indicated that this site is slightly polluted according to the Q-Scheme and good quality water according to the BMWP Scores. Visual observations of these sites indicated slight eutrophication at both sites as areas of excess algae growth was evident. In terms of invertebrates found at these sites, Order Plecoptera, Family Perlidae was recorded, Family Heptageniidae was found, 4 different families of the Order Coleoptera was recorded and 3 different families of the Order Ephemeroptera (mayflies) were found, Family Baetidae, Family Heptageniidae and Family Ephemerellidae which again was super abundant. Family Gammaridae was super abundant at this site and families of the Order Diptera found at this site included Family Dicranata which is the daddy-longlegs larvae. Invertebrates found above Callan Town included 2 families of mayfly, Family Baetidae and Family Heptageniidae, Family Gammaridae was super abundant, 3 families of the Order Diptera were recorded, Family Chironomidae, Family Simuliidae and Family Tipulidae which is the Crane fly larvae. 4 families of caddisfly were recorded, Hydropsychidae,

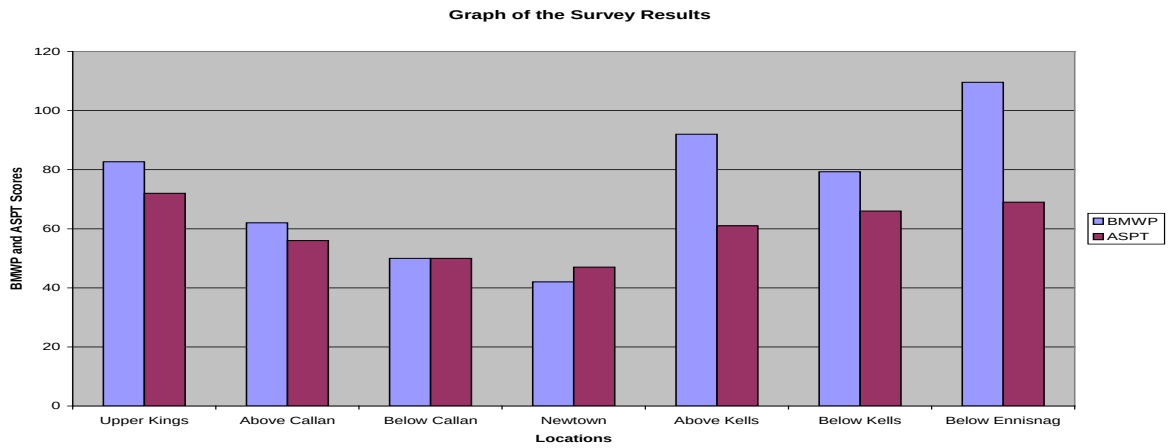
Rhyacophilidae, Limnephilidae, and Philopatamidae. Below Callan town, a sample was taken directly below the waste water treatment plant. The biological water quality indices indicated that this site was moderately polluted (Q-Scheme) and had poor quality water (BMWP score). Visual observations of this site indicated the complete covering of the benthos with a thick algae growth and high levels of eutrophication. At this site a scum or a layer of raw sewage was evident on top of the water surface. In terms of invertebrates found at this site, leeches were abundant, the Families Erpobdellidae and Glossiphoniidae were recorded. Family Chironomidae was super abundant at this site, and the individuals collected were bright red due to high levels of haemoglobin being produced by these invertebrates in response to very low levels of dissolved oxygen. Family Gammaridae was super abundant at this site as well as two families of caddisfly, Hydropsychidae and Rhyacophilidae. The sample taken at Newtown which is about 2km below the wastewater treatment plant even had a lower invertebrate diversity index although levels of eutrophication were not as severe. According to the Q-Scheme this site was moderately polluted and had poor quality water according to the BMWP scores. The same invertebrates were found at this site with the single exception of the Family Elminthidae which is a beetle larva. The other samples taken along the Kings catchment except the sample taken at Ennisnag, indicated that the Callan sewage treatment plant is having an adverse effect on the Kings ecosystem. At Ennisnag, the water quality indices have shown that the natural recovery of an aquatic ecosystem had taken place, with the Q-Scheme rating of Q3-Q4 (Slightly polluted), and according to the BMWP Scores this site had moderate to good water quality.

With respect to sewage outflows into the Kings River, while carrying out this project for the Nore River trust, raw sewage was observed flowing into the Kings River at Kings Bridge in the middle of Callan town. This site was above the sewage treatment plant, and on three visits to this site which were two weeks apart raw sewage was observed flowing into the Kings River. However this outflow has been reported to Kilkenny County Council since 2008 according to the Kilkenny People newspaper. According to the report in the paper the sewage is coming from an overflow pipe and residents have complained to the Council on a number of occasions. Again according to the report in the Kilkenny People, a senior engineer with Kilkenny County Council stated that the outflow at Kings Bridge relates to a dedicated overflow from the public sewer network to the Kings River. As a result of pervious incidences of overflow at this location, Kilkenny County Council has undertaken structural works to the public sewer so as to ensure that the over flow operates in accordance with

overflow design requirements. Also in a report in the Kilkenny People on the 6/07/2010, Kilkenny County Council had confirmed that there are ongoing, unauthorized sewage outflows to the Kings River in the vicinity of Callan Business Park.

Biological conclusion of the benthic macroinvertebrate composition of the Kings River and the effect of sewage outflows in the vicinity of Callan town.

According to the results of the samples taken from above and below the sewage treatment plant it is obvious that the plant is having an undesirable effect on the quality of the water of the Kings River. Above the treatment plant the diversity of invertebrates is greater than that below the treatment plant. Below the treatment plant there is an abundance of Chironomidae larvae (bloodworms) and leeches which are not present above the treatment plant. It is obvious that invertebrates that require low levels of dissolved oxygen are dominating the community below the treatment plant indicating that levels of dissolved oxygen below the treatment plant are low. This conclusion is also backed up by the lack of organisms requiring high levels of dissolved oxygen. In terms of the Kings River ability to support juvenile salmon and trout below the treatment plant, the ecosystem is on the verge of being seriously polluted which in turn would have detrimental impacts on these fish species leading to fish kills. Pollution levels occurring in the river below the treatment plant is just one status above that which is recommended for an aquatic ecosystem to support juvenile salmon and trout. If the treatment plant was operating to EU standards then this undesirable effect on the water quality would not occur. Under the Water Framework Directive which requires all member states to achieve at least "good status" in their surface waters by 2015, the Kings River would fail to meet this target which will have serious consequences for Kilkenny County Council.



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