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ENVIRONMENT
AGENCY

Brown Trout Habitat Assessment on the River Bela Catchment (As Recommended by the Strategic Fisheries Stock Assessment Task Group 1995)

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Summary

The Environment Agency (EA) and its predecessor the National Rivers Authority, undertook strategic fish stock assessments in 1992 and 1995 on the River Bela catchment. These surveys found low numbers of brown trout (*Salmo trutta*) at some sites. Following this, habitat evaluation assessments were undertaken on the eleven poorest sites

Factors probably responsible for declining trout populations on the three main tributaries of the Bela catchment, include:

1. Overgrazing by farm stock.

2. Lack of suitable cover for parr.

3. The absence of suitable spawning areas.

4. Existing potential of certain areas within the catchment not being utilised, due to poor dispersal.

Habitat Improvement Schemes (H.I.S) are discussed and prioritised.

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1. INTRODUCTION

As part of the Environment Agency's responsibilities to maintain, improve and develop fisheries, areas on the River Bela where it is thought potential fish stocks could be improved by habitat enhancement exercises have been highlighted. These are based upon findings in the Strategic Fisheries Stock Assessment of the River Bela Catchment 1995, with Reference to the 1992 Survey (D.J.F. McCubbing & R.Britton, 1995). It is considered that the full potential of these sites, (based upon relative comparisons, within the national database, under the national classification system, (Mainstone *et al*, 1994) is not being fulfilled.

2. DESCRIPTION OF STUDY AREA

The River Bela and tributaries pass through a generally lowland, heavily farmed area to the South east of Kendal and Milnthorpe. The river has three main tributaries, Saint Sundays Beck (partly known as Stainton Beck), Peasey Beck and Lupton Beck. These meet to form the River Bela, just north of Milnthorpe.

3. SITE SELECTION

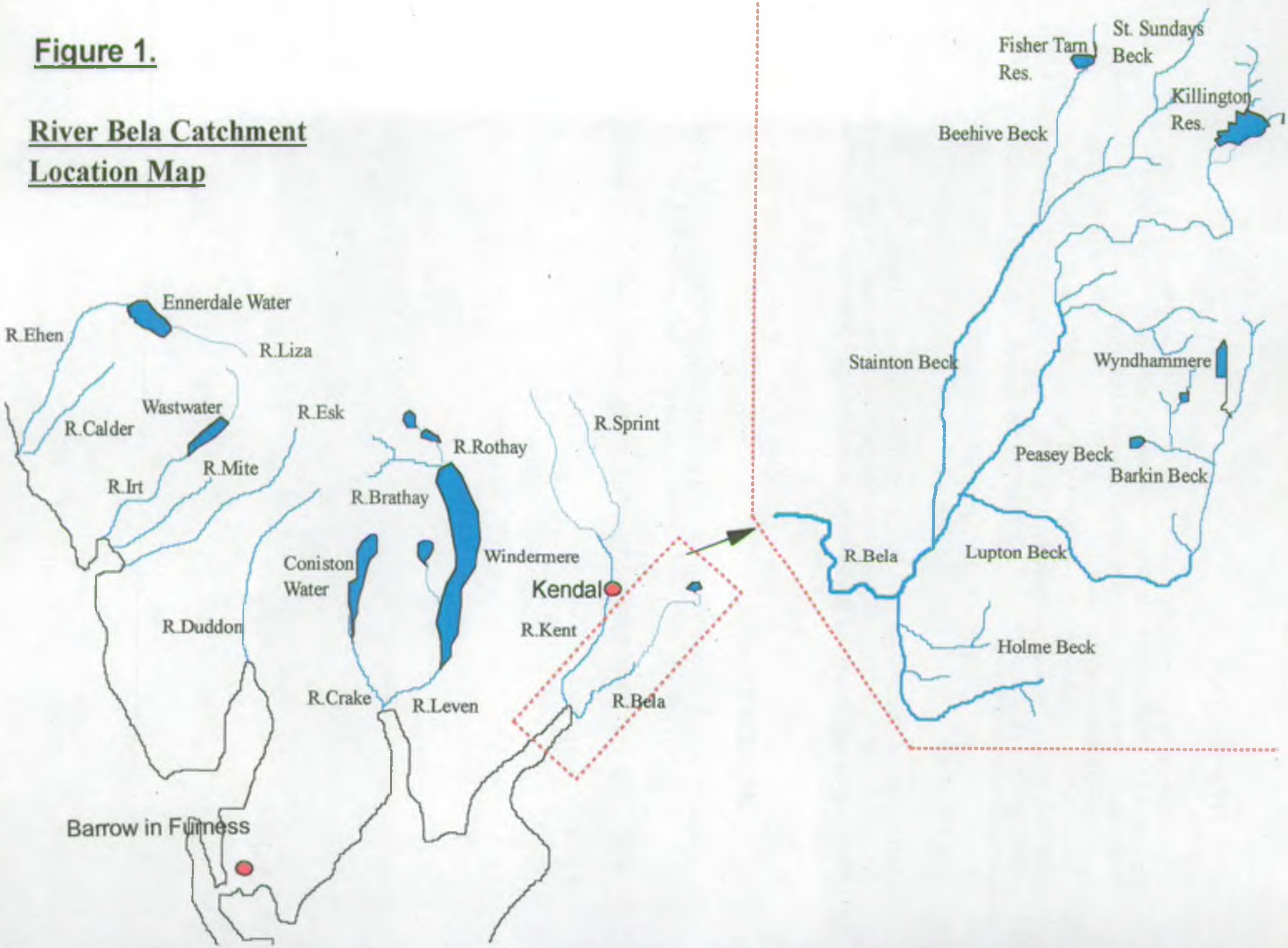
Overall, trout production within the catchment has generally remained stable, although some areas have exhibited areas of consistently low or decreasing trout production (figure 1, table 1).

Table 1. Sites targeted for habitat evaluation exercises as highlighted in the 1995 report.

Species	Age Class	Site	Relative Score	
			1992	1995
Trout	Fry	219	d	e
		220	d	e
		235	d	d
		218	e	e
		216	e	e
Trout	Parr	214	d	e
		216	e	e
		210	d	e
		207	d	d
		218	d	d
		220	d	e
		232	d	d
		235	e	d
		236	e	d
		237	e	e

Figure 1.

River Bela Catchment Location Map

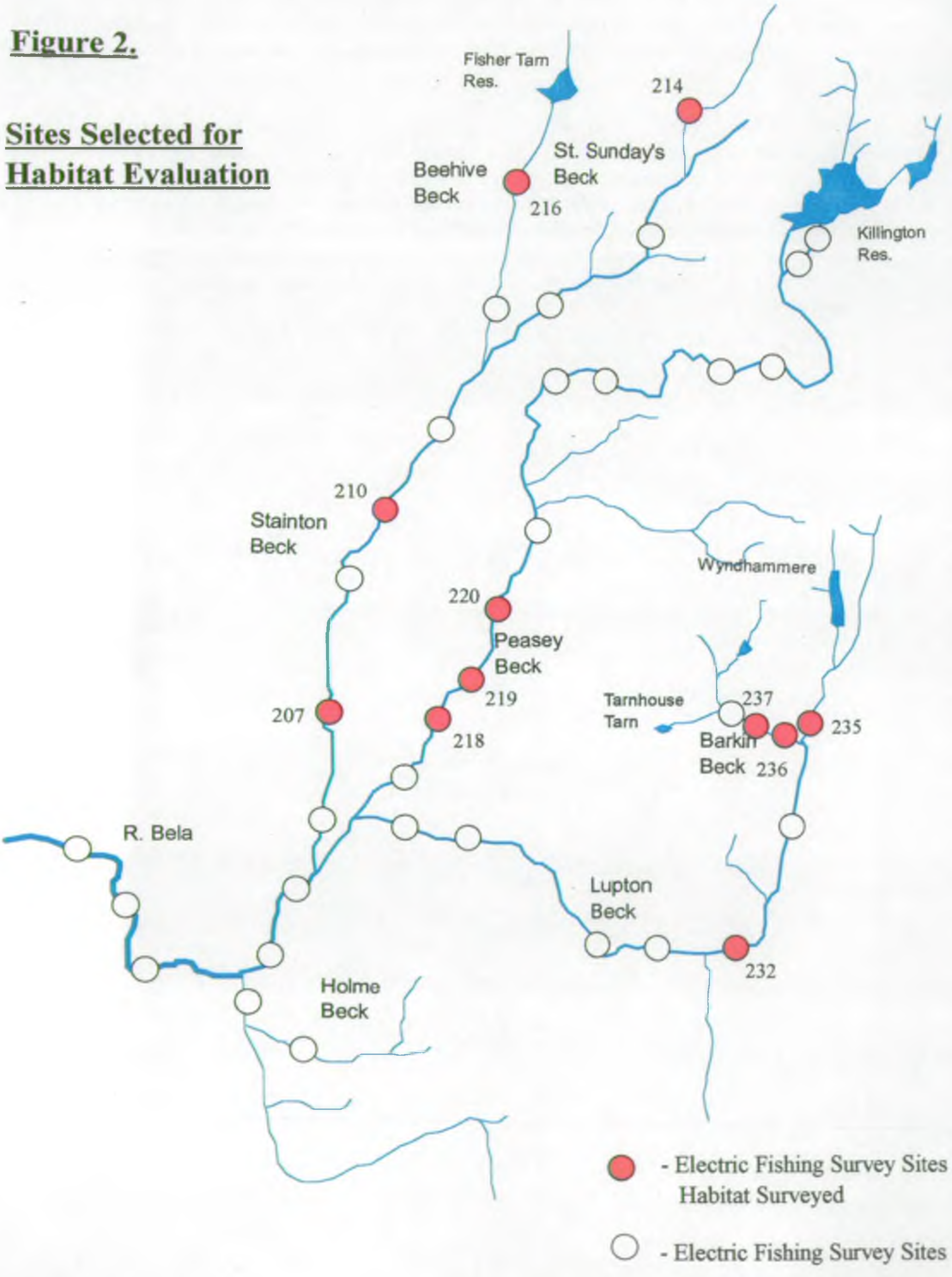


For both the 1992 and 1995 surveys, a total of 38 sites were fished. The 1995 survey highlighted eleven areas of consistently poor and declining trout production (both fry and parr). Based on comparative relative density scores, these eleven areas were selected for habitat evaluation exercises

Poor relative density scores could be caused by restricted spawning substrate, restricted access for adult fish and/or poor juvenile habitat. A water quality survey in the spring of 1995 found water quality to be good throughout the catchment. The catchment, was only recently opened up to migratory salmonids in 1989, by the construction of a fish pass at Beetham Weir (on the main River Bela). Since then increased densities of salmon on all suitable sites have been found. It is therefore areas of poor trout production which are of primary concern. It is not thought that increased salmon production is resulting in a detrimental effect on trout production due to differing habitat requirements.

Figure 2.

Sites Selected for Habitat Evaluation



4. METHODS

4.1. The criteria addressed in assessing habitat quality are as follows and are drawn from 'A Working Guide to the Assessment , implementation and post project monitoring of fisheries habitat improvement schemes' (McCubbing & Locke, 1996).

4.1.2. Survey area: All sites were of a 50m length, marked out with a tape. Width measurements were taken at 5m intervals, and the cross-sectional wetted area calculated.

4.1.3. Substrate: The formation of the substrate is broken down into the following categories;

Bedrock	
Boulders and Rocks:	> 25cm
Cobbles:	6 - 25cm
Gravel:	0.2 - 6cm
Sand and Silt:	< 0.2cm

Each substrate type is recorded as a percentage of the total wetted area.

4.1.4. Cover:

Cover is defined as the area (expressed as a percentage of the section stream bed area) providing refuge for a > 10cm trout. Each type of in stream cover is determined as a percentage of the whole reach cross-sectional area. Cover criteria is broken down into the following categories.

Undercut Banks:
Areas where water has eroded away the material under a stream bank, but the upper portion has not slipped into the water.

Boulders:
Rocks, stones and boulders found in streams providing protection to fish.

Tree Roots:
Bank gets eroded away to leave a dense root system.

Overhanging Vegetation:
Overhead vegetation should be less than 30cm above the water surface.

Branches:
Log and branch debris present in the stream.

Other:
Anything else which is present in the river which can provide in stream cover. Eg. walls, weed etc (caution should be exercised with seasonal, cover eg. weed).

4.1.5. Flow: Flow type is recorded throughout the site, and is expressed as a percentage of cross - sectional area. Flow criteria are broken down into the following categories:

Shallow Riffle (< 30cm):
Shallow swift flowing section of stream where the water surface is broken.

Deep Riffle (> 30cm):
As above with water depth greater than 30cm.

Pools:
Slow or still water with a velocity of less than 10 cm/sec. It will not form eddies behind a metre rule held vertically against the flow.

Deep Glides (> 30cm):
Section of stream where the water velocities are greater than 10 cm/sec, (so to form eddies behind a metre rule), but the surface is smooth.

Shallow glides (< 30 cm):
As above with water depth less than 30 cm.

4.1.6. Shading: The percentage of river shaded by woodland.

4.1.7. Fencing: Whether or not the river is fenced, and is it effective?

4.1.8. Drying Up: Is the river prone to drying up?

4.1.9. Land Use: Land use is determined around the site. Where more than one use is present, the percentage composition is determined.

4.1.10. Bank Erosion: Areas of bank erosion caused either by water undercutting the bank and subsequent widening of the site, or the erosion of banks by farm stock/vehicles/persons, these can also be responsible for substrate disturbance, particularly hazardous where redds are present.

4.1.11. The presence of braiding: Areas where the substrate protrudes through the water surface causing channelling. The protrusions are measured, and the number of sites counted.

4.1.12. The presence of shoulders: Areas where fragments of substrate are deposited by slower moving waters (usually on the inside of bends or meanders).

4.1.13. Additional Information: Any other information that may be considered relevant.

4.1.14. Biological Production Assessment: In order that invertebrate production may be assessed within a site, a one minute kick sample is taken. The resultant samples transferred into a convenient receptacle are identified, and categorized by number (See appendix.2). Any other details or comments are recorded.

4.2. Analysis of Data (Site Prioritization)

4.2.1. Habitat Quality Score, (H.Q.S):

The assessment of habitat quality is based upon both flow and cover characteristics. Data is entered into the DataEase version 4.2 database, which assigns a score according to the suitability of the habitat for salmonids. A good variety in flow conditions (i.e, that which would suit the requirements of the various life stages of both salmon and trout) coupled with good cover availability will score high on a scale of 1 to 10. The opposite would occur to a flow regime weighted heavily towards say pool or deep glide, coupled with low cover availability.

4.2.2. Measure of Total Productivity, (T.P):

Based upon data collected during both the 1992 and 1995 strategic fisheries stock assessment surveys, salmonid production is calculated and a score attributed. With two surveys having been undertaken it is possible to assess site trends (i.e, those which have been consistently poor, declined in fish population numbers or improved).

The score attributed to either fry or parr salmonid densities is taken from the density classes as derived for salmon in the national classification system. It uses elements of fry and parr classes to give higher scores to sites that produce a diversity of age classes rather than just a high density of one age class of salmonid. Sites with high production and diversity of age class are deemed to be of the best quality.

The two six class tables used in scoring salmonid productivity (one for salmonid fry and one for salmonid parr), and the scores attributed to them are laid out in appendix 1.

4.2.3. Biological Production of Invertebrates, (B.P.S):

Data collected on invertebrate numbers (appendix 2) are categorized and assigned a score, those sites scoring highest are deemed to contain the most available fish food.
Sites are scored as follows:

Food Resources	Score
Abundant	100
Good	75
Moderate	50
Poor	25
Very Poor	0

In achieving a priority rating for each, the following equation is used:

Priority = (BPS/HQS)/TPS (Scores will range from 0.1 to 100)

Priority Score < 2

Scores less than two are either limited by biological productivity and are unsuitable for habitat improvement works without first increasing invertebrate productivity or currently support a good total salmonid productivity.

Priority Score 2 - 10

Scores above two but below ten may already have good habitat but may have other factors limiting production. This could be limited resources of adult spawners or a lack of suitable spawning medium in the area. Alternatively medium to low biological production may be limiting fish production. Examination of individual scores will determine what is the case.

Priority Scores 10 - 100

Scores greater than ten have increasing merit for improvements works, with priority for works lying with the highest scoring sites.

The use of other data collected in the field, is available to collate with priority score data. This ensures that all aspects of a site are covered and possible habitat improvement schemes considered.

5. RESULTS

Table 2. Illustrating scores achieved by target sites

Site No.	Tributary	BPS	HQS	TP	Priority
207	Stainton	50	1	4	12.5
210	Stainton	25	8	7	0.45
214	St. Sundays	50	4	5	2.5
218	Peasey	25	1	3	8.3
219	Peasey	100	6	4	4.17
220	Peasey	25	4	5	2.08
232	Lupton	25	4	6	1.04
235	Lupton	50	3	4	4.17
236	Barkin	50	3	8	2.08
237	Barkin	50	4	5	2.5
216	Beehive	100	3	0	33

Stainton Beck

Over the last four years Stainton Beck witnessed an overall decline in both trout fry and parr numbers. Relative scores on the vast majority of sites show scope for improvement.

The Beck primarily consists of shallow riffle areas with deep and shallow glides present to a lesser extent. The substrate predominantly formed of cobble, also holds good gravel areas, with one of the sites surveyed exhibiting redds (site 207). Areas of cover are seasonally low, the majority being provided by areas of in stream vegetation (ranunculus), overhanging vegetation and small areas of undercut bank.

Biological production within the beck is satisfactory, dominated by mayfly with lesser quantities of caddis and gammarus also present. The mean BPS for the three sites surveyed on the beck was 46.6.

Land use in the area is mainly pastoral, with small areas of deciduous woodland present on parts of the beck. All pastoral land is grazed by both sheep and cows, with only a small amount of effective fencing present (< 10%). Consequently numerous areas of eroded bank are present along the entire length of the beck, and riparian vegetation is minimal. There are no obstacles along the length of the beck likely to prevent the upstream migration of fish.

Site No 216, u/s Spate Bridge, Beehive Beck

No fish have been recorded on this site either in 1992 or 1995 (class e). There is an impassable fall downstream. Total production is obviously 0, and a priority rating of 33 was calculated.

HQS is 3, providing 2% cover from overhanging vegetation, and a flow regime of 85% shallow glide and 15% shallow riffle.

Biological productivity scored 100, with prolific numbers of caddis, mayfly and gammarus.

Substrate is 60% cobble, 30% gravel and 10% sand and silt. Land use is pastoral, with banks exhibiting signs of wear from grazing along their lengths. Part of the site (approx 20m) has a hedge along one bank; the rest is unprotected.

Site No 207, D/S Rowell, Stainton Beck

It can be seen from table 2, that site 207 holds one of the highest priority score ratings (12.5). Since 1992, relative scores for trout parr have decreased (from class d to e), with the relative class for fry remaining stable at class b.

An extremely low HQS indicates poor flow and cover factors. Ninety percent of the flow consisted of deep glide, with the remaining 10% being shallow glide. The presence of good numbers of fry can be attributed to the strong current at this site. Cover availability is poor, with just 1% present, provided by a small area of undercut bank.

The BPS score of 50, comprised mainly of caddis and gammarus with mayfly present to a lesser extent.

The substrate presents a good mix of cobble and gravel (50% and 42% respectively), 2 redds were observed during the survey.

Land use is 100% ungrazed deciduous woodland with no signs of bank erosion present. The site is 15% shaded.

A weir of approximately 4 feet in height is present about one mile downstream. This is shown to be passable by the presence of salmon on sites above it.

Site No 210, Skettle Gill, Stainton Beck

A rise in relative density score from e to d for trout parr occurred between 1992 and 1995 on this site, whilst trout fry relative density scores dropped from class a to class c. The total production score for the site is 7 and the priority rating 0.45.

The site scored a good HQS of 8, the flow regime comprising mainly of shallow riffle and shallow glide favours fry, with percentage cover extremely high brought about by the presence of 30% weed cover, this is inevitably seasonal, providing good habitat during the summer months.

The low BPS (25) comprised mainly of mayfly and to a lesser extent gammarus.

The substrate was shown to be a good mix, with 65% cobble and 30% gravel. Bank erosion is severe, with one bank exhibiting erosion caused by farm stock along its entire length. There is no shading present.

Site No 214, Raw Head Farm, St Sundays Beck, (Plate 1)

A drop in relative score (from class a in 1992 to class c in 1995) has occurred, the relative class e for parr is low, and has remained stable since 1992. Total production score 5 and priority rating 2.5 were calculated.

An HQS score of 4, could be better. Flow is complementary to the requirements of fry, with 85% shallow riffle and 15% shallow glide. Cover is minimal, weed comprising of 2% (seasonal), and a small amount of overhanging vegetation giving an extra 1%.

The BPS score of 50 comprised mainly of mayflies and gammarus.

Plate 1. Site No 214, Raw Head Farm, St Sundays Beck, (SD 569 920)

The substrate is predominantly cobble (75%), with boulders and rocks (embedded) 10% and gravel at 10%, the remainder being made up of sand and silt. Land use is 100% pastoral, with a fairly steep gradient on one side of the beck. A land drainage pipe flows into the beck approximately half way down the site. Bank erosion is widespread (caused by farm stock), with six sites totalling 12m of eroded bank. There is no shading present.

Peasey Beck

Peasey beck between 1992 and 1995 experienced a decrease in trout fry numbers. Trout Parr numbers were shown to increase. Relative scores for both life stages are shown to be poor. The three sites surveyed , although all within only three kilometres of each other, exhibited quite varied characteristics.

Flow characteristic studies showed areas of shallow riffle to be most prolific, followed then by deep glides, shallow glide and pools. All sites scored well for cover, with undercut banks, overhanging vegetation, boulders and rocks, allochthonous cover and tree roots all contributing.

Biological production between sites is extremely varied, with caddis and gammarus dominating. Stonefly and mayfly are present to a lesser extent.

The substrate is mainly cobble, boulders and rocks. Sand and silt exist to a lesser extent and there are small amounts of gravel present, although on parts of the beck (especially the upper reaches on unsurveyed stretches) there are areas of detritus (allochtonous material, quite possibly washed down from Killington reservoir) fouling what could be excellent spawning substrate. These areas exhibited signs of organic enrichment, with the beck running a deep red/brown colour (plate 2).

Plate 2. Peasey Beck (SD 584 899, Unsurveyed). Organic Enrichment

Land use as with all the catchment is mainly pastoral, although small areas of residential land also exist. Cows and sheep are present on most areas. Fencing is minimal and overgrazing exists, which has inevitably lead to severe bank erosion, and minimal riparian vegetation growth. Obstructions (e.g weir , d/s Crooklands) to migratory fish exist, it is however known that these are passable, although it is likely that they hold an influence over distribution. A large waterfall exists between sites 222 and 223, although during periods of high flow it is possible that this is passable.

Site No 218, Crooklands, Peasey Beck

Relative scores between 1992 and 1995 remained stable, with fry scoring a very poor class e and parr scoring class d, total production was measured at 3, and a priority score of 8.3 calculated..

The low HQS of 1, is brought about by the poor flow characteristics of the site (95% deep glide). Cover availability levels however were good, with tree roots, overhanging vegetation and undercut banks (plate 3), providing the majority of the 5% score.

Plate 3. Site No 218. Crooklands. Peasey Beck. (SD 535 835)

The low BPS of 25 consisted solely of chironomid larvae.

The substrate is predominantly formed of cobble (68%), with gravel areas comprising a further 15%. Land use can best be described as wasteland on one bank, and recreational on the other, A small sewage treatment plant is present, with a discharge pipe emptying into the site.

Between 10 and 20 metres downstream a weir (approximate height 3 feet) is present. Bank erosion, shoulders and braiding are not present. The site is 30% shaded by riverine trees. It is known to be passable to salmonids due to the existence of salmon fry on sites (219 and 220) upstream.

Site No 219, Kaker Mill, Peasey Beck

The relative score for fry on this site has remained stable at a low class D since 1992, parr scores have increased from class C to class B. Total production was measured at 4, with a priority score of 4.17.

The HQS of 6, can be considered to be reasonable, with excellent cover availability (non-seasonal 10%) consisting of undercut banks, tree roots, boulders branches and logs. Flow characteristics composition is 70% shallow riffle, 20% shallow glide and 10% pool.

An extremely good BPS of 100 was primarily formed of caddis, gammarus and chironomid larvae, with stoneflies and mayflies also present.

The substrate is formed mainly of cobbles (90%) with the rest being made up of gravel. Land use is 50% deciduous woodland and 50% improved pasture. Two sites (approx 2m in length each) exhibited bank erosion on the pastoral bank. The river is 25% shaded by the deciduous woodland on one bank.

Site No 220, Gatebeck Bridge, Peasey Beck

A decrease in both fry and parr relative scores has been witnessed since 1992 (class D to class E). Total production was measured at 5, with a priority rating of 1.25.

HQS score 4, is formed by 4% cover, 64% shallow riffle with the rest split evenly between deep riffle, deep glide and shallow glide. The substrate has very little gravel present (5%), and is formed mainly of cobble 83% and embedded boulders and rocks (10%).

The low BPS of 25 was formed mainly of caddis, with mayfly and gammarus also present.

Land use is 100% improved pasture, (no effective fencing present) with 8 sites exhibiting a total of 18m erosion. One shoulder is present (8m), with one site of braiding (on the downstream side of an island) approximately 5m in length. It is thought that this area of braiding will run dry during periods of low flow. The site is 50% shaded by riverine trees.

Farleton, Barkin and Lupton Beck

Of the 10 sites surveyed, in 1995 on this region of the Bela catchment, six experienced a rise in fry numbers since 1992, from poor/ average relative class scores to average/good. The other four remained stable with a generally good class structure B/C. Parr numbers have however decreased, and relative scores are very low.

The beck is generally shallow (< 30 cm), dominated by areas of shallow riffle and glide. Deeper areas (>30 cm), account for approximately 25% of the overall flow regime. Cover availability is poor, with the majority being seasonal in stream vegetation. Undercut banks, overhanging vegetation and boulders exist in minimal quantities.

The average BPS of 44 was formed mainly of mayfly and caddis, with gammarus and stonefly present to a lesser extent.

The substrate is primarily formed of cobble, with good gravel areas also present. Sand and silt deposition is a problem on certain sites. The vast majority of land use is pastoral, with bank erosion from cattle poaching (damage caused to banks by hooves of farm stock) having caused widening in certain areas which has in turn led to severe braiding with parts of the original bank isolated within the main river (plate 3, Spittle Bridge). Numerous sods of eroded earth are present fouling the substrate, rock revetment bank repairs have been successfully undertaken (approx 100m d/s Spittle Bridge) in an effort to prevent bank erosion caused by cattle poaching and undercutting (this has been successful). A series of 3 weirs exist along the beck (not impassable) which are likely to have an effect on the distribution of migratory species.

Site No 232, Spittle Bridge, Lupton/ Beck, SD 581 807

An increase in fry relative score has occurred since 1992 (D to C), with a decrease in parr (D to E). Total production score is 6, and a priority rating of 1.04 having been attributed.

HQS 4, is comprised of 9% cover, predominantly formed of large sods of earth and grass from eroding banks lying on the substrate, undercut banks provide a further 2% cover. The flow regime is varied with 8% pool, 45% shallow riffle, 35% deep glide and 12% shallow glide.

The low BPS (25) consisted of just mayfly and caddis.

The substrate holds 10% sand and silt, 60% cobble and 30% gravel. Land use is 100% improved pasture (no fencing), with severe bank erosion caused by farm stock (9 sites totalling 30m in length), with large lumps of the banks present on the substrate. One site of braiding (approx 11m), is thought to run dry in the summer, leaving two distinct channels. There is no shading present. 8 redds were reported in this stretch (4/12/96), it was observed that cattle were present in the beck, opening a threat of redd trampling and disturbance.

Site No 235, Blea Beck Bridge, Lupton Beck

Fry relative scores on this site have remained stable since 1992 (class D) with parr numbers having improved (from class E to class D). Total production score is 4, with a priority rating of 4.17.

A low HQS of 3 is formed by a presence of 30% deep glide, 35% shallow glide, 10% deep riffle and 25% shallow riffle. Cover availability is 4%, provided by areas of undercut bank, tree roots and branches.

The BPS score (50) shows mayfly to be dominant, with caddis and gammarus also present.

The substrate consists of 85% cobble, 10% boulders and rocks and only 5% gravel.
A large fallen branch into the beck has lead to the backing up and diversion of water, this will eventually lead to braiding on the downstream side of the obstacle, especially during periods of low flow. One side of the beck is walled (effective) the other side is grazed. The banks along the entire length are downtrodden, (plate 4). The site is 15% shaded.

Site No 236, U/S Goodmickle Bridge, Barkin Beck

An increase in both relative classes for fry and parr has occurred since 1992 (class D to B and class E to D respectively). A good total production score of 8 was achieved, and a priority rating of 2.08 derived.

A low HQS was recorded, due largely to the lack of cover (< 1%), the flow regime showed the site to be mainly shallow (45% riffle and 45% glide), with both deep riffle and deep glide forming the extra 10%.

Biological productivity (50), was predominantly mayfly, with caddis and gammarus also present.

The substrate is largely cobble (85%), with gravel forming the remainder. Land use is improved pasture, with severe bank erosion (6 sites measuring a total of 65m) having been caused by grazing. The site is 20% shaded by large trees.

Plate 5. Barkin Beck. u/s site 236. (SD 586 831). Severe bank erosion.

Site No 237, Beckside, Barkin Beck

Since 1992 The fry relative class has increased from C to B, with the parr class having remained stable at a low class D. Total production score is 5, and priority score 2.5.

Available cover is virtually non-existent (< 1/5%), although the flow regime is good with 80% shallow riffle, 15% shallow glide and 5% pool. These factors resulted in an HQS of 4.

The BPS (50), is dominated by mayfly, with stone fly and gammarus also present.

The substrate is 80% cobble, 15% gravel and 5% sand and silt. Land use is improved pasture (unfenced), and erosion damage on both banks caused by farm stock is prolific. The site is not shaded.

6) HABITAT REQUIREMENTS OF BROWN TROUT

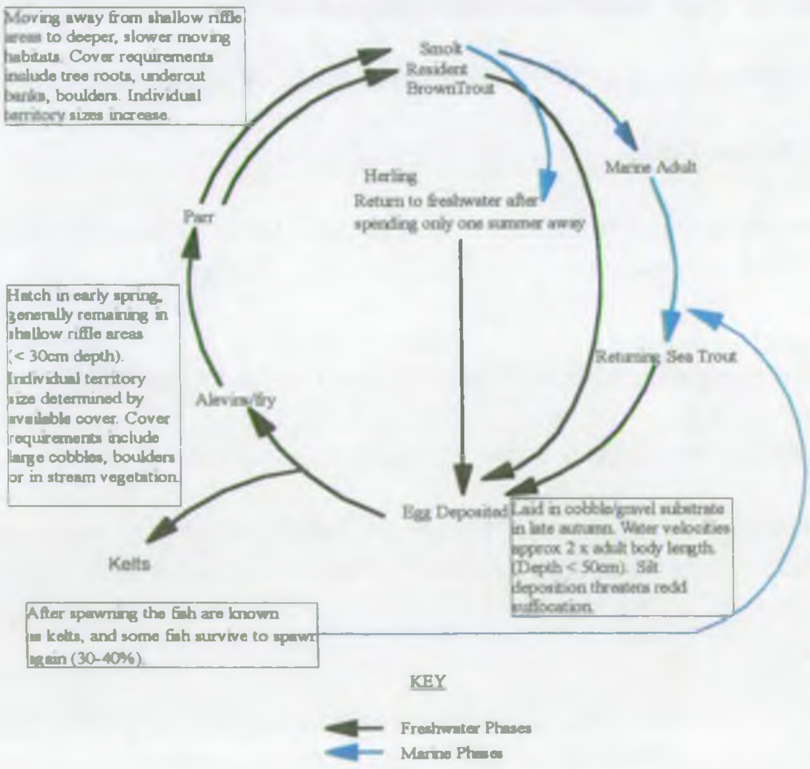
Habitat requirements of brown trout vary according to the life-stage of the fish. The life cycle and habitat requirements are illustrated in figure 3.

From a fishery management viewpoint, ascertaining the actual requirements of each individual life -stage is not a difficult process as a lot of work has been undertaken in this field, (Crisp & Carling, 1989,91; Ottaway et al, 1981; Elliot, 1967,1994; Fausch, 1984; Karlstrom, 1977). The most complex task is getting the' mix' of these elements correct to such a degree that each life-stage has the maximum availability of suitable habitat within a reach or catchment, without impeding the requirements of others.

6.1) Spawning Adults

Typically the adult is found to spawn at the tail end of a deep glide or pool as the stream bed rises to a riffle. At such sites there are three main criteria involving habitat suitability that must be fulfilled; water velocity, water depth and substrate.

<u>Figure 3. The life cycle and habitat requirements of the brown/sea trout, *Salmo trutta.*</u>



Velocities inevitably vary within reaches/catchments, and much work has been done in attempting to determine preferred velocities. It is known that the adults will spawn in water velocities up to twice the female body length/sec and in water depths generally under 50 cm, but no less than body depth. The substrate whereon the redd is cut, will be an area of cobble/gravel, the particle size will vary according to the ability of the fish to dislodge it.

This will invariably be related to the size of the fish, compaction of the substrate, particle angularity, the binding of particles by siltation, in stream vegetation and water velocity. It is not known if the adult fish will actively seek preferential spawning sites within a reach, or will merely settle for any habitat deemed suitable at the time of spawning.

6.2) Embryonic Survival

For optimum embryonic survival to occur (there will be mortalities), a good flow of water through the redd is required, in order to maintain dissolved oxygen at sufficient levels. A build up of sediment within the redd will reduce embryo permeability, increase the Biological Oxygen Demand and hamper emergence. The redd is cut in such a manner that its angularity produces a down draft of water through the eggs. However, increased velocities (i.e caused by spates or discharges upstream), or disturbance from farm stock, can flatten the redd, giving rise to increased mortality.

6.3) Emergent Fry

On hatching, alevins generally exit the redd, and disperse downstream, either by active swimming, drifting or a combination of the two. Eventually, be it by choice or chance, a station is adopted a couple of centimetres off the bottom, behind some form of cover (i.e, large cobbles, boulders, or in stream vegetation. This cover is not only important as protection from currents, but also, visual blocking from other fry, decreases territorial aggression. Thus, a site with more cover is capable of holding more individual territories and, provided food availability is adequate the carrying capacity of the system is increased.

Fry dispersal through a reach is important from a management viewpoint in that it holds implications for spawning site dispersal. The more spread out suitable spawning grounds are, the better fry dispersal and survival will be achieved when density dependant mortality and carrying capacity are considered.

6.4) Fry

Upon first feeding, fry will lie stationary in the current (< 50 cm/sec), picking off small invertebrates in the drift. Again cover is important (see above). Another aspect affecting territorial behaviour of fry, (once yolk sac absorption has occurred) is food availability (i.e, the more dense a food supply, the smaller an individual territory need be).

Fry favour shallow riffle areas (depth < 30cm). However, as growth occurs, these requirements become less relevant.

Favoured substrate type at this stage tends to be cobble (6-25 cm), as opposed to the cobble/gravel substrate of the nursery grounds. Typically trout will favour marginal areas of a reach (unlike salmon, which tend to favour a central feeding station) where cover provided by perhaps tree roots, undercut banks or overhanging vegetation is available.

6.5) Parr

As maturation proceeds, habitat requirements invariably alter. Moving away from the shallow/ riffle areas, trout parr seek out deeper, slower moving habitats, for example, deep glides (>30 cm) or pools. As the fish becomes larger, so will its territory requirements, and food supply needs. Cover is still equally important, from a territorial/predation and current velocity viewpoint. Areas of undercut banks, tree roots, overhanging vegetation and boulders (as opposed to cobbles) are important. In stream vegetation may now also provide cover and a source of food. A weed choked area though would have a detrimental effect on the site, as water velocities would be decreased and deposition of sediment occur thus choking the substrate.

6.6) Adult

Once mature (either as brown or sea trout) it is usual for a downstream migration to occur. Sea trout smolts will enter feeding grounds in the estuaries/seas, whilst the brown trout will seek out deep pools or glides. Territorial rights at this stage are vitally important, more so now than water velocities and substrate composition, territorial behaviour becomes aggressive. Pecking orders are established usually in favour of larger fish. Still feeding off invertebrates, and to a much lesser extent small fish, both food supply and cover availability are extremely important factors when individual territory size requirements are considered.

Figure 4.

Prominent Bank ErosionLupton Beck

Plate No. 8

Site no. 236
u/s Goodmickle Bridge

SD 586 831

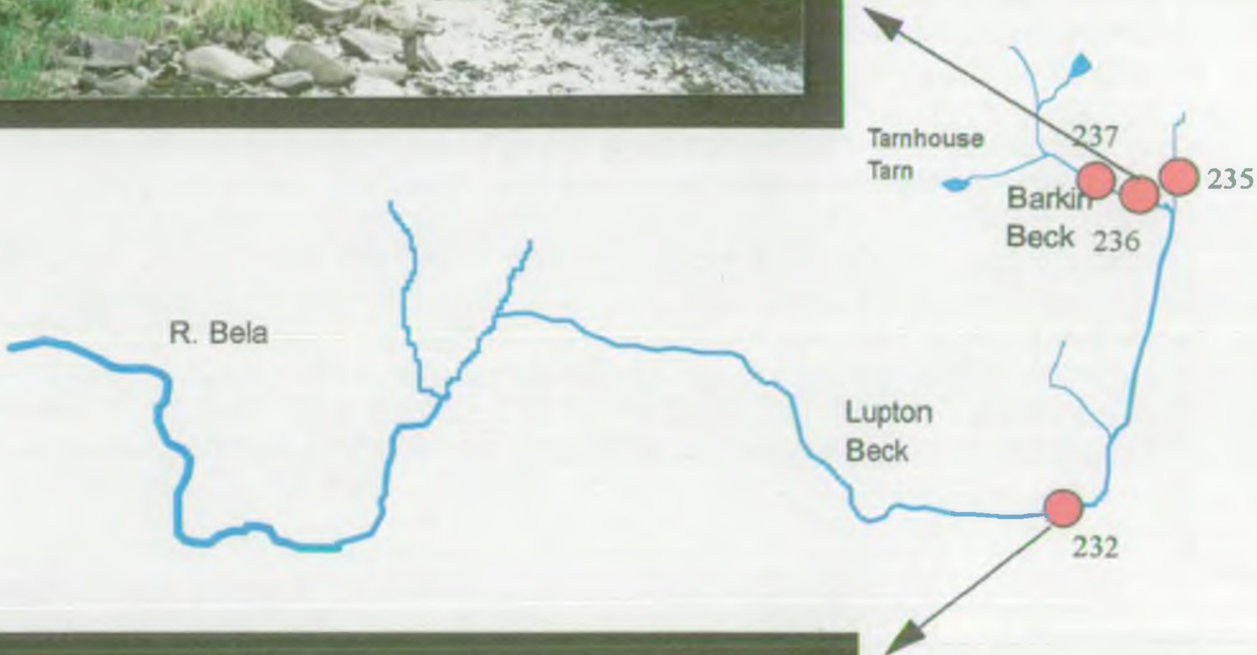


Plate No. 9

Site No. 232
Spittle Bridge

SD 581 807

7) DISCUSSION

This section not only considers the causes of poor recruitment at the various life-stages, but will outlines suggested habitat improvement schemes. The recommendation section prioritises these proposals.

Stainton Beck

Comparisons of results from both the 1992 and 1995 surveys, indicate a drop in both fry and parr numbers. Currently the 10 sites on the beck and associated tributaries hold average/good relative classes for fry (1 class e,5 class c, 1 class b and 3 class a) and average/poor classes for parr, (4 class e, 2 class d, 2 class c, 1 class b and 1 class a).

Flow requirements of both fry and parr are met by shallow riffle and deep glide areas respectively. Although poor HQS ratings, are apparent on three of the four sites selected for habitat assessment, the general 'mix' of flow characteristics throughout the reach is good, when considering the requirements of all life stages. These low HQS scores can therefore be attributed to a lack of suitable cover.

Good gravel bed areas exist that are suitable spawning habitat, and cobbles suitable as cover for fry are prolific. Boulders and rocks (i.e parr cover) are present only minimally.

The upper reaches of Beehive beck are prone to siltation. This area is inaccessible to migratory fish due to impassable falls downstream of site 216. The construction of a fish pass in this area would not be financially viable for the amount of habitat that would be made available to migratory fish. BPS score in this area was 100, therefore food availability would not be a limiting factor in fry survival. Good cobble and gravel bed areas exist above the falls. If de -siltation was undertaken, the opening of what would be excellent nursery grounds would be possible by the introduction of fry (transferred from other reaches of the catchment). The process if these grounds are to be exploited should be carried out on an annual basis.

Gravel jetting upon this reach, (a technique now widely used by fishery managers) is a relatively low cost technique, involving the cleaning of gravel with a high pressure water jet from the top of a reach down. It should be carried out shortly before spawning (and not during). It is unfortunate that this area of potentially excellent fry habitat is currently not being utilized.

As already mentioned, the reach is extremely prone to bank erosion due to farm stock poaching. Prior to the implementation of an HIS, this problem should be addressed by the introduction of fencing.

As is common throughout the whole catchment, both sheep and cows graze these areas and therefore, a wire mesh fence with double stranded barbed wire would be necessary. The buffer zone between the fencing and the stream will be no less than 2m.

The cobble substrate provides limited cover for fry. Seasonal in-stream vegetation will, at certain times of year, provide cover from water flows and contribute to the reduction in size of individual territory requirements. The placement of in-stream boulders, to these areas would provide further cover and the breaking up/increased velocity of the current will aid in the prevention of further sedimentation.

The introduction of fencing along the entire length of the beck would be an answer to improving fry and parr numbers. Cattle poaching is causing prolific bank erosion. As well as destroying redds, widening the becks and reducing flow velocities, (which will eventually lead to siltation, and loss of spawning habitat), establishment of bank side vegetation is inhibited.

The creation of a buffer through fencing would encourage the growth of overhanging vegetation, giving rise to increased cover availability for both fry and parr (example, plate 6)

Plate 6. The creation of a buffer zone to encourage riparian growth

Riparian trees exist on parts of the beck. These areas provide small amounts of allochthonous cover, suitable for both fry and parr.

The further planting of such areas would assist both cover availability and erosion defence.

Peasey Beck

Since 1992, six of the eleven sites surveyed have experienced a decrease in fry numbers the other five have remained stable. None have shown an increase. Relative class scores are average/poor (4 at class e, two at class d and five at class c). Overall parr numbers have increased throughout the reach, due mainly to a good rise in numbers on sites 217 and 222, where relative class scores rose from class e to b on both. Relative class scores are average/poor (5 class e, 2 class d, 3 class b and 1 class a).

For fry, both flow and substrate habitat requirements are met (shallow riffle/cobble areas) and it is therefore unlikely that these factors are responsible for the fall in numbers. Analysis of results upon the three sites surveyed reveals a lack of gravel areas thus, unless good and well dispersed areas suitable for spawning are present, it is unlikely that good numbers of fry and subsequent dispersal will occur within the reach. Siltation/detritus is present to a high degree on the upper reaches of the beck (0 - 3.5 Km d/s Killington). These factors will be proving detrimental within these nursery areas to survival during the embryonic stages.

Possible answers to the above listed problems lie in gravel jetting (in order that suitable nursery areas maybe re-instated). Once completed these upper reaches would benefit from the transference of fry. It is thought that not many mature adults exist above Old Hutton due to what are considered to be impassable falls.

Another method in habitat manipulation whereby spawning areas are created, is in the addition of gravel. Prior to initiation of such a proposal, maximum flow velocities should be examined to ascertain the impact of Killington Reservoir discharges on newly planted areas. This application should only apply to areas downstream of Old Hutton if maximum return of migratory salmonids is desired. In addition, maximum flow velocities with respect to the structural stability of trout redds requires investigation.

Where parr are concerned, all habitat requirements are met. Good areas of cover were present on all sites with areas of deep glide, riffle and pools existing. Although relative classes could still be improved, the increase in numbers since 1992 is encouraging and it is hoped that this will continue to increase.

A prolific problem on the beck, is again erosion. This is predominantly caused by livestock, although increased water velocities caused by reservoir discharges is possibly a contributory factor.
As with Stainton Beck, Peasey Beck would benefit to a great extent from the introduction of fencing in pastoral areas. This further improvement of cover availability (resultant from the introduction of a buffer zone), would accelerate already increasing parr production. Furthermore, a decrease of cattle poaching and subsequent fouling of the substrate will likely be observed. Redd damage through the action of cattle entering the stream will also be prevented.

Farleton, Barkin and Lupton Beck

This reach has exhibited an excellent increase in fry numbers since 1992, although scope for improvement of relative classes exists. The reach has gone from an average/poor rating to what is now average. It is hoped that these encouraging figures will continue to rise. Currently one site is class D, 4 class C, 4 class B and 2 class A.

Parr numbers have decreased since 1992 from average/poor to poor. Currently five sites are class E, four class D, one class C and one class A. With increasing fry numbers apparent, this possible 'bottleneck' in parr production is of primary concern.

Flow regimes meet the requirements of both fry and parr, although the reach is dominated by areas that favour fry.

The predominantly cobble substrate provides cover for fry, with good gravel areas deemed suitable as spawning habitat for adults. Available cover for parr is minimal and the answer to the decline in numbers is likely to lie in factors influencing this issue. Introduction of areas of cover onto selected sites where it is thought parr congregate, for example in stream brush or boulder placement in order to reduce the needs of individual territory sizes, could be implemented.

The primary cause of the decrease in parr densities, is probably lack of suitable cover. Growth of overhanging stream side vegetation will be encouraged by the establishment of a buffer zone. Bank erosion was most prominent on this reach. Areas in dire need of repair exist, for example the site directly above Spittle Bridge is widening to such an extent, that in low flow conditions sediment deposition will occur, fouling what is, but soon won't be, suitable spawning habitat. If fencing is to be introduced, rock revetment repairs (plate 7), should be carried out in conjunction with fencing in order to prevent further widening, on certain sites.

Plate 7. Rock revetment repairs against bank erosion, d/s Spittle Bridge, Farleton Beck. (SD 575 800)

Invertebrate production is sufficient to support a larger head of fish, and is not considered to be a limiting factor in increasing trout production.

The creation of deeper areas (>30 cm) will open new habitat opportunities to parr, this however, could well be of detriment to fry habitat. With fry numbers increasing markedly, it would be unwise to put these areas at risk.

Existing habitat suitable for parr, is currently not being exploited to its full potential, and HIS schemes in these areas will not only increase parr production, but will do so with little or no risk to fry habitat.

It is likely that the weirs/dams existing on the beck, although not impassable will, be affecting the upstream movements of mature adults. A study into the design of weirs/dams and possible implications into the hindrance of upstream migrations could prove to be useful .

8) OVERVIEW

Factors probably responsible for declining trout populations on the three main tributaries of the Bela catchment, are:

1) Overgrazing by farm stock.

2) Lack of suitable cover for parr.

3) The absence of suitable spawning areas.

4) Existing potential of certain areas within the catchment not being utilised, due to poor dispersal.

If production is to be increased throughout the catchment these factors should be addressed. The interaction of HIS's with each other must be considered. Alleviating problems affecting fry production will pay no dividends, unless applied in conjunction with solutions to factors affecting parr production. Certain implementations will favour both life stages (for example, the creation of a buffer zone, in order to increase cover provided by overhanging vegetation). Others in specific areas, will target a specific life stage.

9) PRIORITISED RECOMMENDATIONS

1) The introduction of fencing (meshed/double stranded barbed wire), on as much of the catchment as is possible. Priority areas are:

a) Where other HIS schemes will be implemented.

b) Where it is considered that, present damage is most prominent and production potential highest (Lupton, Farleton and Barkin Becks, Figure 4, plates 8 and 9).

c) Those where pastoral land is grazed most heavily.

d) Any other areas that it is thought will benefit from this procedure.

2) (In conjunction with no. 1, where applicable) The introduction of 'temporary' areas of cover, (in stream brush and boulder placement) until a fertile buffer zone is established, on sites which currently are not achieving to their full potential, although habitat characteristics (excluding cover) are deemed suitable for parr production.

a) The annual transference of fry into the upper reaches of Stainton Beck (Beehive Beck), from areas of high production within the catchment, in order to gain a more even distribution, (figure 5). This should be carried out in association with gravel jetting procedures on areas of Beehive beck.

b) The provision of areas of cover suitable for parr, on sites which will not benefit from the application of no.1, but currently provide suitable habitat (e.g, site 207, Stainton Beck).

4a) An assessment of maximum flow velocities on Peasey Beck during times of flood and discharge from Killington reservoir.

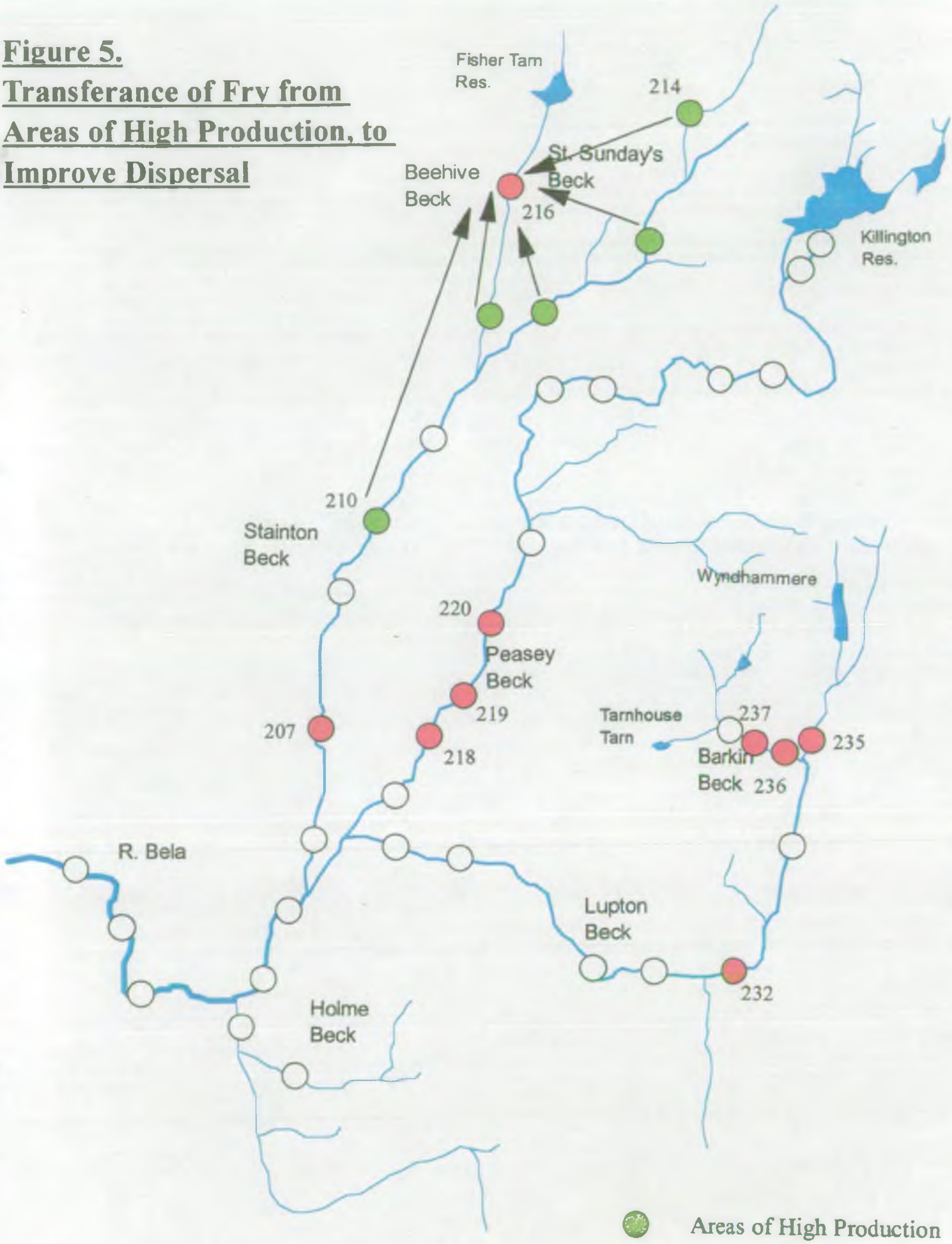
b) The gravel jetting of areas on upper reaches of Peasey Beck (above Old Hutton), and the annual transference of fry into these areas (currently inaccessible to mature adults, Subject to 4a).

5) An assessment of spawning habitat dispersal (awaiting report), and the possible creation/rehabilitation of spawning areas throughout accessible reaches of the catchment. (Peasey Beck, subject to 4a), in order that better fry dispersal is achieved. This in certain areas will alleviate the option of 2a.

5a) An investigation into the effect that weirs/ dams are having upon the upstream migration of adults.

6) Post project monitoring of any applied proposals.

Figure 5. Transferance of Fry from Areas of High Production, to Improve Dispersal



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APPENDIX 1

Salmonid Productivity and Scores Attributed to them for the Prioritisation of Habitat Improvement Works

TOTAL PRODUCTIVITY DENSITY	CLASS	SCORE
SALMONID FRY		
0	F	0
0.01 - 9.0	E	1
9.01 - 23.0	D	2
23.01 - 45.0	C	3
45.01 - 86.0	B	4
>86.01	A	5
SALMONID PARR		
0	F	0
0.01 - 2.56	E	1
2.57 - 5.0	D	2
5.01 - 10.0	C	3
10.01 - 19.0	B	4
>19.01	A	5

APPENDIX 2

INVERTEBRATE DATA

SITE NO	207	MAYFLY	0	
		STONEFLY	1 - 10	
		BEATIS	0	
		NYMPHS	10 - 50	
		CADDIS	10 - 50	
		GAMMARUS	10 - 50	
		ASSELUS	0	
		OTHER	tubifex	1 - 10
	210	MAYFLY	0	
		STONEFLY	10 - 50	
		BEATIS	0	
		CADDIS	0	
		GAMMARUS	1 - 10	
		ASSELUS	0	
		OTHER	0	
	214	MAYFLY	10 - 50	
		STONEFLY	0	
		BEATIS	0	
		CADDIS	1 - 10	
		GAMMARUS	1 - 10	
		ASSELLUS	0	
		OTHER	leeches	1 - 10
			worms	10 - 50
			pupae	1 - 10
	216	MAYFLY	50 - 100	
		STONEFLY	0	
		BEATIS	0	
		CADDIS	1 - 10	
		GAMMARUS	50 - 100	
		ASSELUS	0	
		OTHER	worm	1
	218	MAYFLY	0	
		STONEFLY	0	
		BEATIS	0	
		CADDIS	0	
		GAMMARUS	0	
		ASSELUS	0	
		OTHER	chironomid	1

219	MAYFLY	1 - 10	
	STONEFLY	1 - 10	
	BEATIS	0	
	CADDIS	10 - 50	
	GAMMARUS	10 - 50	
	ASSELUS	0	
	OTHER	10 - 50	
		chironomids	
			leeches
220	MAYFLY	1 - 10	
	STONEFLY	0	
	BEATIS	0	
	CADDIS	10 - 50	
	GAMMARUS	1 - 10	
	ASSELUS	0	
	OTHER	1 - 10	damselfly
			leeches
			snails
232	MAYFLY	1 - 10	
	STONEFLY	0	
	BEATIS	0	
	CADDIS	1 - 10	
	GAMMARUS	0	
	ASSELUS	0	
	OTHER	1 - 10	caterpillars
			worms
235	MAYFLY	10 - 50	
	STONEFLY	0	
	BEATIS	0	
	CADDIS	1 - 10	
	GAMMARUS	1 - 10	
	ASSELUS	0	
	OTHER	1 - 10	leeches
			snails
			worms
236	MAYFLY	50 - 100	
	STONEFLY	0	
	BEATIS	0	
	CADDIS	1 - 10	
	GAMMARUS	1 - 10	
	ASSELUS	0	
	OTHER	0	

237

MAYFLY	10 - 50
STONEFLY	1 - 10
BEATIS	0
CADDIS	0
GAMMARUS	1 - 10
ASSELUS	0
OTHER	1 - 10 worms