PONDS of the PHOENIX PARK

Current Ecological Status and Future Management

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TABLE OF CONTENTS

1. INTRODUCTION

Phoenix Park is located 2.5 km west of Dublin City and consists of 1752 acres (Ordnance Survey of Ireland, 1983) of parkland, sports facilities and bike and walking trails, as well as an intersecting network of public roads. This magnificent urban feature (Plate 1), which is a designated National Historic Park, is the largest of its kind in Europe (Reilly, 1993) and provides a valuable amenity to the city.

Plate 1. Wellington Memorial Monument situated in the Phoenix Park, Dublin City.

The park contains a series of ponds that are dispersed through the entire area (Figure 1). These represent a valuable amenity for local residents and visitors alike. This reflects the abundant and diverse wildlife that has been attracted by these watercourses, and the landscape features that they add to the various walks and trails that dissect the park. As the ponds are in such close proximity to the large urban area that is Dublin City, they have also attracted angling interest since their construction in the late 19th century.

In April 2007, the Central Fisheries Board (CFB) was commissioned by the Office of Public Works (OPW) to conduct a survey of the six ponds and one open stream within the park’s boundary to assess the baseline ecological status of these urban aquatic habitats. A subsequent request to survey the two ponds within Dublin Zoo was made in September 2007. The survey was conducted as part of the newly reinitiated Phoenix Park Management Plan. The plan was initially formulated in 1986. The declared objectives were to “conserve the historic landscape character of the park, encourage recreational use and public appreciation, conserve the natural and other values within the park and develop a harmonious relationship between the park and the community” (Phoenix Park Management Plan, 1986). The field survey was conducted by a scientific team from the CFB between June and October 2007.

1.1. Terms of Reference

The objective of the survey is to provide baseline information on the water quality status of eight ponds and one stream within the boundary of the park and on the biological communities that are resident in them. The survey aims to provide details regarding the speciation and community structure of the aquatic plant, macroinvertebrate and fish populations present in these aquatic habitats. Little historic information is available on the fish stocks, general ecology or physico-chemical status of these watercourses.

1.2. Report Presentation

In the present document, the ecological status of each of the watercourses is presented separately. Each account presents details regarding the morphology of the watercourse, supported by a detailed bathymetric map. The position of the pond in respect of waterflow within the park is indicated. A brief description of the pond follows, highlighting features that might influence the biological or ecological status of that ecosystem (e.g. concrete embankments, shading by tall deciduous trees, islands, among others). A more detailed description of the biological communities follows. Where information is available, comparisons with previous work conducted in these urban waters is made. Each account concludes with recommendations for the future management of that watercourse.

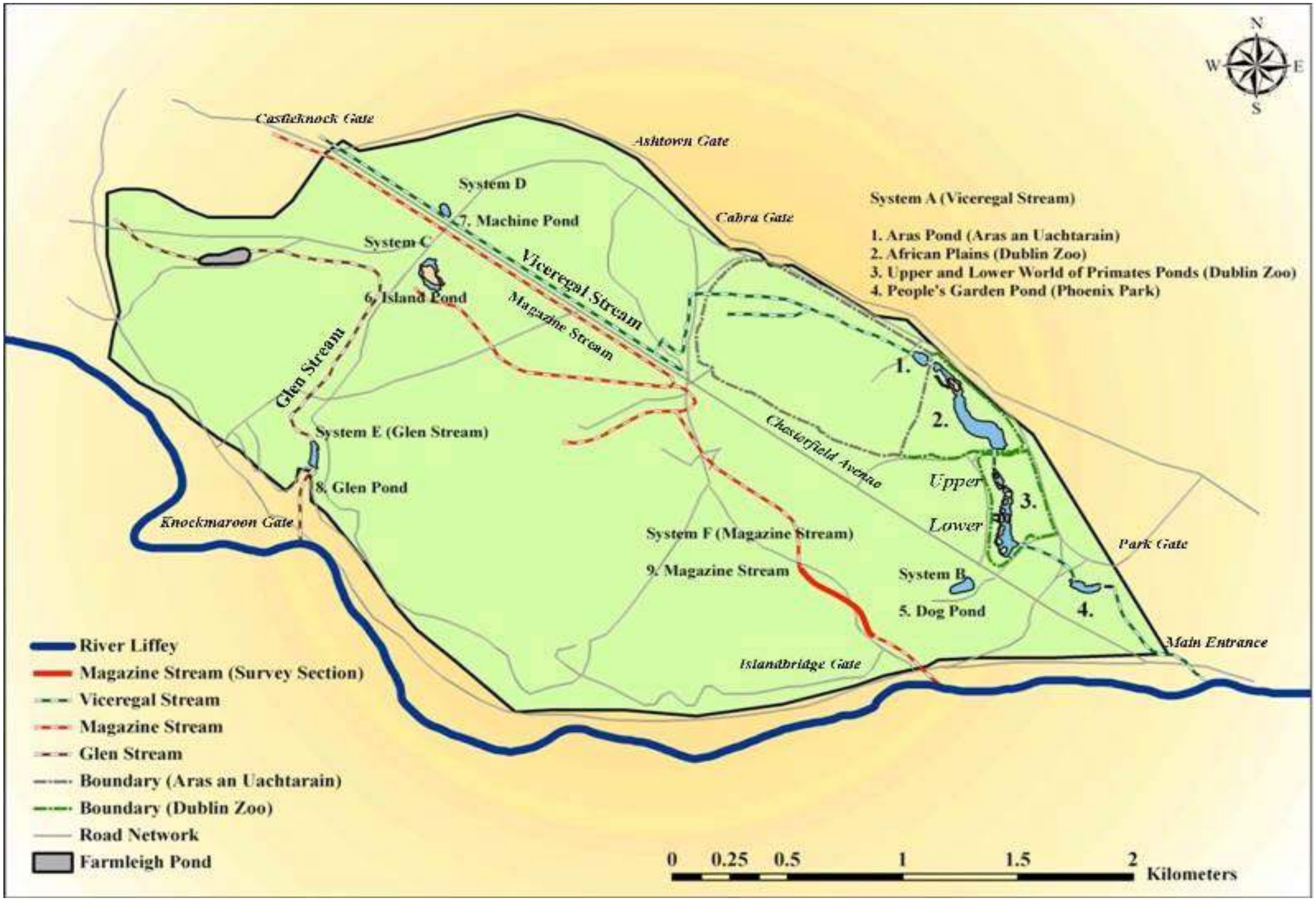

Figure 1. Map of the Phoenix Park, Dublin City, showing the water bodies that were surveyed by the CFB in 2007. An expanded A3 version of this Figure is presented at the back of this report.

1.3. Water Supply Network

The geology of the park consists of a limestone basin with glacial tills and gravel (Creighton, 2000). Its topography comprises of a natural northerly-southerly decline towards the River Liffey, which flows in an east-westerly route along the entire southern border of the park. Three streams (the Glen, Magazine and Viceregal) flow through the park, supplying water to several ponds (Figure 1). These streams have been heavily modified and long sections have been culverted over the years, but they still represent an important drainage facility, as well as an important water source for several of the ponds in the park. Some of the streams connect several ponds before leaving the park (e.g. Viceregal Stream, Figure 1), while some ponds have no apparent connection (e.g. Dog Pond, Figure 1). For the purposes of this report, the streams have been categorised as separate systems, demarcated A-F (Figure 1). For exa++mple, the Áras Pond, fed by the Viceregal Stream, is situated at the head of System A. From here the stream flows through an underground pipe into the African Plains Pond in Dublin Zoo, which in turn discharges into the Upper and Lower World of Primate Ponds through underground culverts. The water continues through a short, steep (*c.* 45^{o}) channel into the People's Garden Pond and *via* an underground culvert, to the River Liffey (Figure 1). It is probable that ponds fed from the one water supply source will have a similar physico-chemistry and closely allied biological communities.

1.4. Pond Design

In the report, ponds are referred to as being of an 'on-line' or 'off-line' design. On-line ponds are created by damming a stream/river and allowing a build up of water in a dredged or naturally occurring depression on the original course of the stream. This ultimately leads to the formation of an artificial pond, whose inflow and outflow is the original stream itself. On-line ponds in the Phoenix Park include the Áras, African Plains, Upper and Lower World of Primates, People's Garden and Glen Ponds. On-line ponds can have one or more inflow points and an outflow, which is commonly situated on the side opposing the inflow. These inflow streams are influenced by fluctuations in levels of rainfall resulting in periods of heavy flow (also known as spates) with good flushing potential, as well as times of limited or no flow. Over time, on-line ponds may develop a characteristic shallowing effect at its inflow. This results from silt and debris deposition received from its water source.

The Island, Machine and Dog Pond are described as off-line ponds. An off-line pond is formed by diverting water away from a stream to form a stand-alone artificial water body.

2. METHODOLOGY

The survey was commissioned to provide a baseline assessment of the water quality condition and the status of the biological communities in the watercourses within the Phoenix Park. Similar methods were employed to collect data in each pond to ensure comparability of results.

2.1. Bathymetry

Bathymetric maps were produced for all of the ponds surveyed. Water depth readings used in the production of the maps were collected using a depth finder (Fishin Buddy ^{tm} 1200) (Plate 2). GPS co-ordinates were recorded concurrently and maps were produced using GIS ARCVIEW 9.2^{tm}.

Plate 2. A Secchi disc being used to determine water clarity. The depth finder (Fishin Buddy tm 1200) can be seen on the boat. People's Garden Pond, Phoenix Park.

2.2. Physico-Chemistry

A limnological analysis of all nine waters was carried out in June and again in October 2007. A list of the physico-chemical variables examined is presented in Table 1. In June, when a boat was available on the ponds, three samples were collected in each pond, one at the inflow and outflow points, and a third from the open water (roughly mid-lake). In October, water samples were collected in the ponds at locations proximal to the inflow and outflow. Results obtained from laboratory analysis of the water samples were assessed by comparing the levels for each parameter to recommended threshold levels (Table 1), as set by the legislation or relevant regulatory bodies. It should be stated that these threshold levels apply to surface waters, such as lakes and canals, and may not be directly applicable to stagnant artificial ponds. For the purposes of this report, however, and in the absence of any directly appropriate legislative standards, these threshold levels provide suitable guidelines for assessing water quality in the Phoenix Park Ponds.

Table 1. Physico-chemical parameters measured during the survey of the ponds and stream in the Phoenix Park in 2007. Summary descriptions of each parameter are presented. Threshold levels are displayed according to appropriate legislation (1) Surface Water Regulations (1989), (2) Bathing Water Quality Standards (1992), (3) Freshwater Fish Directive (1978), (4) Environmental Protection Agency (EPA) Q Values (2001) and (5) Caffrey & Allison (1998).

Parameter	Description	Directive Guidelines
Alkalinity (meq/l)	Presence of bicarbonates formed in reactions in the soils through which water percolates	No mandatory limit, levels above 6 meq/l^{-1} require investigation (Champ, T. pers. Comm.)
Chlorophyll a (µg/l)	Naturally occurring green pigment. Indicator of algae growth in water sources and of trophic status.	No mandatory limit. Levels above 35 µg/l indicate strong eutrophication
Conductivity (µS sec^{-1})	Indicator of ionised salt content and determination of water hardness	(1) > 1000 (µS sec^{-1}) indicate breach
Water Temperature (^{o}C)	Climatically influenced	No mandatory limit. Levels above 30^{o}C would require investigation
Total Phosphorus (TP mg/l)	Natural or added organic matter	(3) 0.063 mg/l (lake / canal) (5) 0.15 mg/l (river / stream)
Molybdate Reactive Phosphorus (MRP mg/l)	Most available for uptake by plants. Accurate measure of potential eutrophication	(5) 0.02 mg/l (lake / canal) (4) 0.05 mg/l (river / stream)
Total Organic Nitrogen (TON mg l)	Derived from organic matter naturally present	(5) 11.3 mg/l
Total Coliforms Faecal Coliforms	MPN test - 37 ^{o}C for 18-24hrs Total Coliforms – All bacteria sources Faecal Coliforms – Bacteria from animal and human waste	(2) >5000 per 100ml indicate breach – Total (2) >1000 per 100ml indicate breach – Faecal

2.3. Aquatic Macrophytes

Aquatic vegetation was recorded in the following categories: emergent, floating-leaved, free floating, submerged and filamentous algae. An eight-pronged grapnel was used to retrieve submerged vegetation in each pond (Plate 3). The majority of species were identified on site. Those species that required more detailed examination were returned to the laboratory for identification.

Plate 3. Sampling aquatic vegetation using an eight-pronged grapnel. In the background is the Machine Pond, near the Castleknock exit of the Phoenix Park.

The relative abundance of each species was estimated using the DAFOR scale, where species are ranked as Dominant (D - >70%), Abundant (A – 30 to 70%), Frequent (F – 10 to 30%), Occasional (O – 1 to 10%) or Rare (R - <1%). Percentage bottom cover (%) was estimated for each species present.

2.4. Macroinvertebrates

Sampling of macroinvertebrates involved an initial walkover survey to identify the various mesohabitats in each pond. A variety of mesohabitats were identified in the Phoenix Park ponds. These included exposed sediments, stands of emergent reeds and areas of submerged or floating-leaved aquatic plants. Macroinvertebrates were collected by continuously sweeping a handnet for a total of 3 minutes through the habitat being sampled (Plate 4). The three minutes of sampling was divided equally between the various mesohabitats that were identified during the walkover survey.

Plate 4. Invertebrate sampling using a sweep net in reed beds (*Typha latifolia*) of the Dog Pond, Phoenix Park.

Samples collected were stored in labelled plastic bags and preserved in 70% ethanol. Processing of macroinvertebrate samples involved washing each through a 0.5 mm sieve and sorting by hand. Macroinvertebrates were identified to species level, where possible, using Freshwater Biological Association identification keys.

2.5. Fish Stocks

A wide range of techniques are available to sample fish populations in freshwater systems (Growns *et al.*, 1996; Hubert, 1996). Fish stocks within each pond were assessed using standardised techniques operated by the CFB (Table 2).

Plate 5. Setting fyke nets in the Dog Pond, Phoenix Park.

Netting methods included the use of multimesh (monofilament) gill nets and conical "Dutch" fyke nets (Plate 5). It is normally desirable to fish nets for a 24 hour period (Caffrey, 2002), including periods of day and night. However, on the recommendation of the Phoenix Park wardens, an alternative strategy was adopted and nets were fished in each pond for a standard 6 hours during daylight, from 9 am to 3 pm. This would avoid the risk of nets being vandalised or removed during periods of darkness. Electro-fishing operations were also conducted along the exposed or reeded margins, beneath overhanging trees, lily beds and within dense macrophyte beds.

Following capture, fish were identified to species level, measured (fork length cm), weighed (nearest gram) and a small number of scales were removed for age and growth analysis (Musk, *et al.*, 2006). The majority of fish were returned alive to the water. Determining the age and growth of fish from temperate freshwaters using scales is a classic, non-destructive method when examining the status of a population. It provides valuable information regarding the structure and health status of the fish population in the water surveyed. Growth rates generated for each species (with the exception of perch, *Perca fluviatilis*) were compared to those from other waters in the country.

Table 2. Fish Stock Assessment methods used during the Phoenix Park Survey in 2007

Method	**Dimensions**	**Description**
Electro-fishing	220v Generator (Positive anode (+), negative cathode (-))	Emits PDC current (Pulsed direct current) at 4 amps to periodically "stun" fish. Used for marginal and shallow waters (under 2m in depth)
Multimesh (monofilament) gill nets	45m long x 1.5m deep	12 mesh sizes, ranging from 5mm to 55mm.
"Dutch" Paired Fyke nets	25m per pair	Conical-shaped benthic nets

Catch Per Unit Effort (CPUE) was used as the primary method of presenting the fish data. CPUE is the "ratio of the total number of an individual species captured by a particular method, divided by the number of times that method is used" (Backiel & Welcomme, 1980). While it is normally possible to compare results from other waters surveyed by the CFB using gillnet capture methods, because of the imposition of an alternative sampling strategy (6 hour versus 24hr netting time), this was not possible. However, as the alternative sampling approach was used in all of the Phoenix Park ponds, catch data may be compared.

3.0. THE PONDS OF THE PHOENIX PARK

A total of nine waters (eight ponds and one stream) were surveyed within the boundary of the Phoenix Park between June and October 2007. Each watercourse will be treated separately, so that the reader may obtain all of the basic information pertinent to that water body.

Dublin Zoo is present within the boundary of the Phoenix Park since its creation in 1831 and is the third oldest Zoo in the world. The CFB was commissioned to undertake a survey of two ponds within the boundary of the Zoo, the African Plains Pond and the Upper and Lower World of Primate Ponds, in September 2007. They are situated between the Áras Pond and the Peoples Garden Pond, which is located in the outer boundary of the park. They are however, connected *via* the same water supply, the Viceregal Stream (see Figure 1), which eventually discharges to the River Liffey.

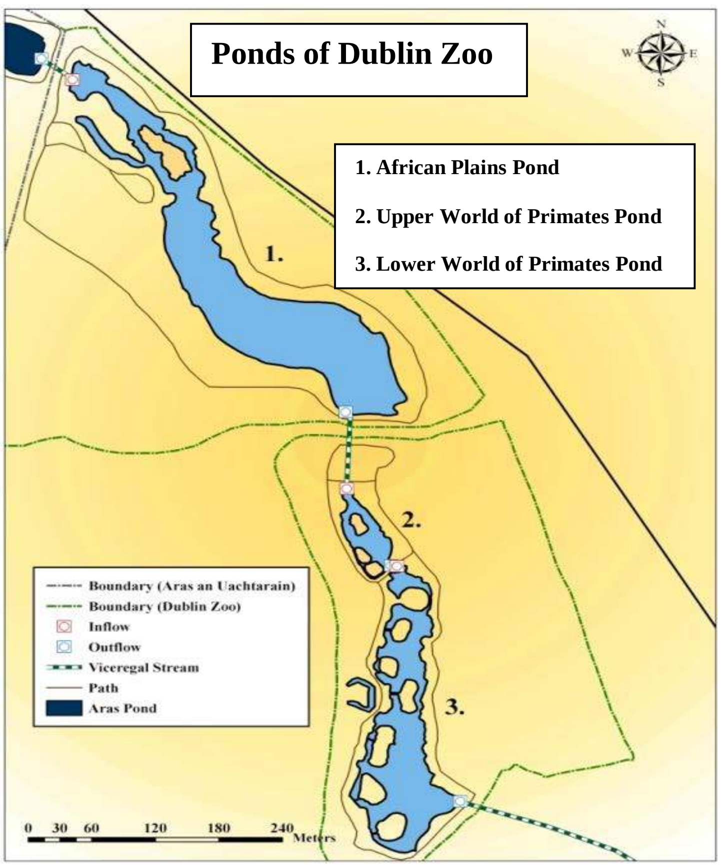

Figure 5. Ponds of the Dublin Zoo complex, Phoenix Park.

3.1. ÁRAS POND (No. 1 - System A)

3.1.1. Introduction

The Áras Pond is situated in the eastern section of the Phoenix Park (see Figure 1). The pond is located within the boundary of Áras an Uachtaráin, and is not accessible to the general public. It is fed by the Viceregal stream, which enters the Park close to the Castleknock Gate and flows underground to feed into the Áras Pond at its north-western end.

Plate 6. The Áras Pond, in Áras an Uachtaráin, Phoenix Park, showing the boathouse to the right of the pond.

It is the first of four ponds on this watercourse, which eventually discharges to the River Liffey (see Figure 1).The outflow is located at the south-eastern end of the pond (Figure 2). Water is discharged from the pond in a south-easterly direction through two large (15-20”) pipes for *c.* 60m to the African Plains Pond in the Dublin Zoo complex (Figure 2). At the time of sampling, the flow into the Áras Pond was negligible.

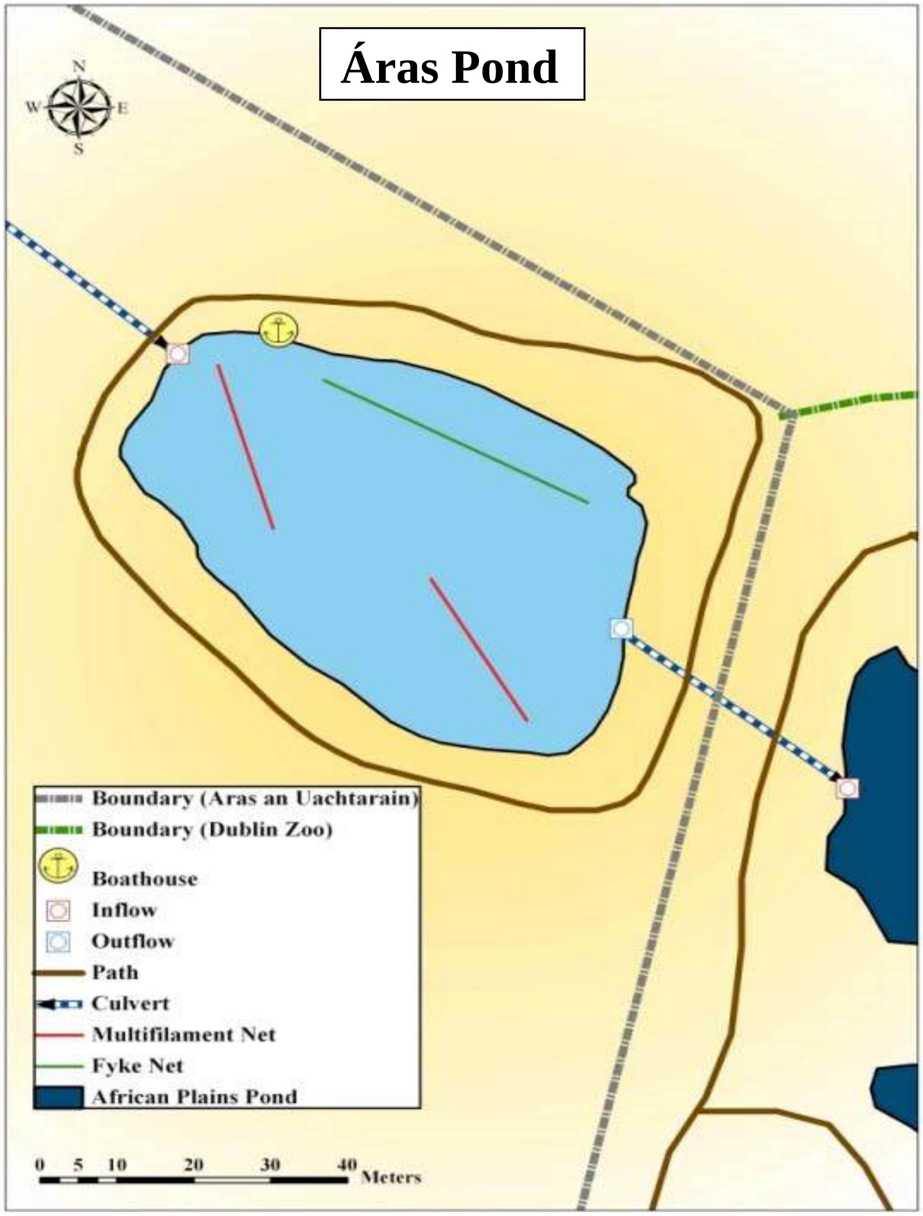

Figure 2. Map of the Áras Pond, Áras an Uachtaráin, Phoenix Park. The African Plains Pond is situated to the southeast, within the Dublin Zoo complex.

The Áras Pond is *circa* 0.28 hectares in area and is roughly circular in shape. The pond has an on-line design, which incorporates both an inflow and outflow. Structures associated with the pond include a stone wall to support the inflow and a large dam constructed from boulder and rock at its eastern end. The northern and southern shores are lined with marginal vegetation (Plate 6).

The Áras Pond is one of the newer creations in the Phoenix Park watercourse network. Prior to 2000 the Áras and African Plains Ponds formed one large water body and both were within the confines of Áras an Uachtaráin. During that year a decision was made to move the boundaries of Dublin Zoo to incorporate a large section of this man-made pond. To facilitate this, dams were constructed to delimit both ponds. The connection between the two was maintained through an underground culvert.

Plate 7. The boathouse on Áras Pond, Áras an Uachtaráin, Phoenix Park. A floating carpet of Amphibious bistort (*Polygonum amphibium*) borders the pond margin in the foreground.

The Áras Pond provides a visual amenity on the grounds of Áras an Uachtaráin. The presence of a boathouse would suggest that the pond was used for boating at some juncture (Plates 6 & 7). Historical records indicate that the pond had been stocked with brown trout (*Salmo trutta*) to provide angling for former President Patrick Hillary. No subsequent fish stocking was conducted by the CFB.

3.1.2. Results

(a) Bathymetry

Water depths in the Áras Pond ranged between 0.4m and 1.4m, deepening towards the outflow (Figure 3). When the survey was conducted in June 2007, the mean depth in the pond was 0.7m.

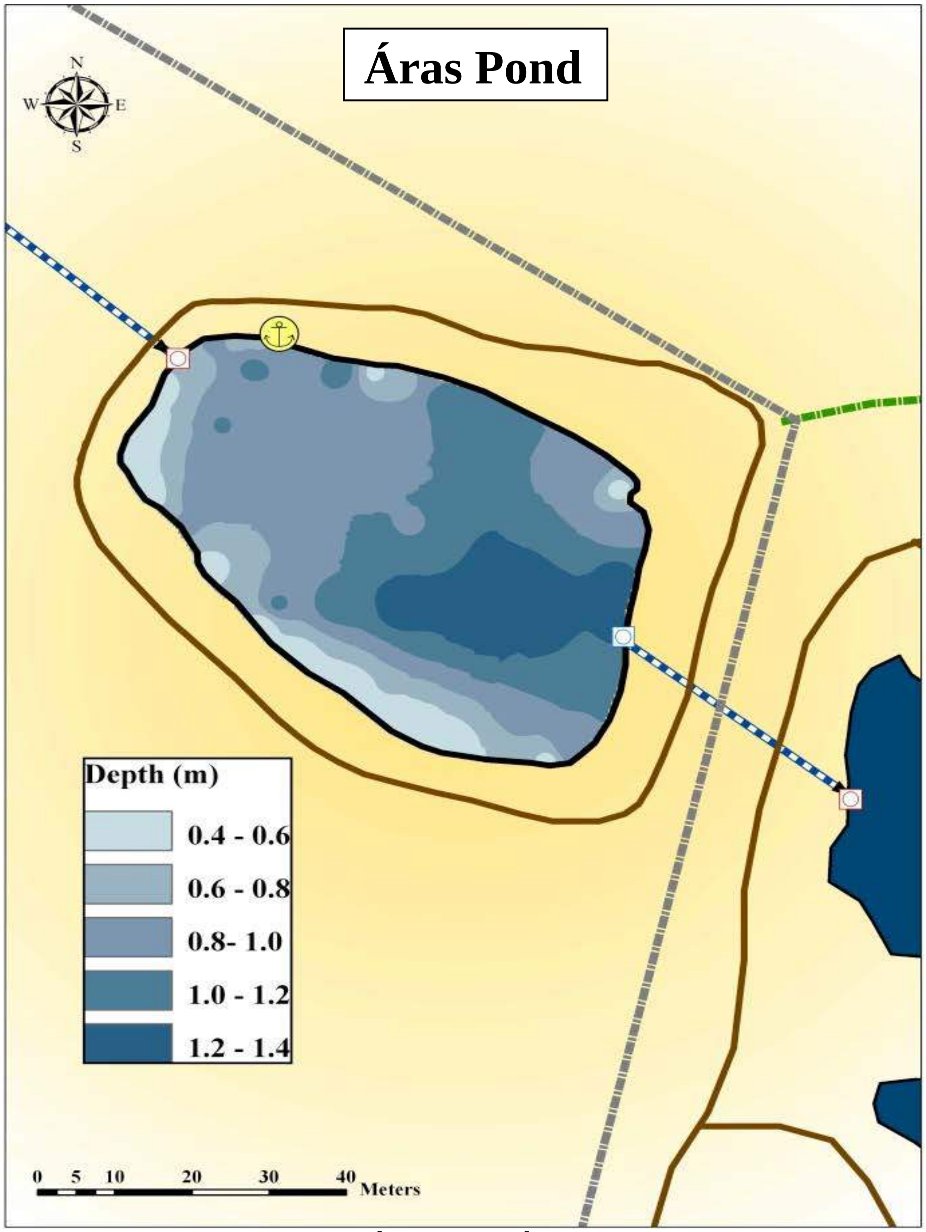

Figure 3. Bathymetric map of the Áras Pond, Áras an Uachtaráin, Phoenix Park. The African Plains Pond can be seen to the southeast.

(b) Water Quality

Physico-chemical analysis of water from the Áras Pond, conducted in June and October 2007, revealed good water quality conditions (Table 3), with all measured parameters within the recommended guidelines (see Table 1). Water temperatures ranged from 15.9^{o}C in October to 18.2^{o}C in June. The highest conductivity reading of 613µS/cm was recorded in June. Corresponding alkalinity levels of 3.87meq/l were recorded in October, categorising the pond as an alkaline watercourse. Water clarity was excellent on both sampling occasions, with Secchi disc measurements recorded at the maximum depth of 1.4m.

Table 3. Physico-chemical data recorded from the Áras Pond, Áras an Uachtaráin, Phoenix Park, during 2007.

Sample Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Inflow	June 07	0.017	<0.006	<0.049	602	2.235	1.474	20	<1	18.2
Mid - lake	June 07	0.024	<0.006	<0.049	589	2.034	1.52	20	<1	17.9
Outflow	June 07	0.018	<0.006	<0.049	613	2.235	1.566	220	<1	18
Inflow	Oct. 07	0.032	<0.006	<0.049	597	3.67	1.79	20	<1	15.9
Outflow	Oct. 07	0.033	<0.006	<0.049	606	3.87	1.704	564	<1	16.1

Chlorophyll readings indicate that the pond has an oligotrophic status, with very low levels recorded (1.47 – 1.79mg/l). Nutrient analysis of the water in the Áras Pond also reflects its healthy status, with concentrations of Total Phosphorus (TP), Molybdate Reactive Phosphate (MRP) and Total Organic Nitrogen (TON) well within the threshold limits that would indicate a risk of eutrophication or pollution (Table 3). Results from bacteriological testing of the water revealed very low counts for both total and faecal coliforms (Table 3). Overall, physico-chemical sampling of the Áras Pond revealed good water quality conditions and the pond would be expected to support a healthy and sustainable flora and fauna.

(c) Macrophytes

An abundant and relatively diverse aquatic macrophyte flora occupied the Áras Pond and its relatively steep margins. Seventeen species were recorded in total (Appendix II). Most of the marginal pond area was vegetated with emergent plants, the most prolific of which were Branched Burreed (*Sparganium erectum*), Water Mint (*Mentha aquatica*), Reed sweet-grass (*Glyceria maxima*), Yellow flag (*Iris pseudacorus*) and Reedmace (*Typha latifolia*). This vegetation maintained a relatively low profile around most of the pond, although occasional tall stands were present (Plate 8). In places, the emergent stands encroached into the pond, occasionally to a depth of 0.4m.

Beyond the emergent vegetation zone, isolated and often large stands of the floating-leaved Amphibious bistort (*Polygonum amphibium)* were present (see Plate 7). Most prominent among the submerged species were Water starwort (*Callitriche* sp. *(*cf. *hermaphroditica*), Fan-leaved crowfoot *(Ranunculus circinatus)* and filamentous green algae. The starwort formed loose and often straggling cushions of light-green vegetation while the stands of crowfoot were relatively inconspicuous on the pond bed. The filamentous algae, comprising mainly *Cladophora* sp. (cf. *glomerata*) and lesser stands of *Spirogyra intestinalis*, dominated the submerged flora. These algae carpeted *circa* 60% of the pond bed and generated surface scums during the autumn months (see Plate 12). A proliferation of filamentous algae is commonly suggestive of organic enrichment but, in the case of this pond, it may be more an indicator of stagnant water conditions following a period of low rainfall.

Plate 8. Marginal aquatic plant communities on a) the northern shore and b) the western shore of the Áras Pond, Áras an Uachtaráin, Phoenix Park in 2007. The wall protecting the inflow to the pond and the boathouse on the north-western shore can be seen in the background (b).

A number of small, relatively unhealthy stands of the Stonewort (*Chara vulgaris*) were recorded from grapnel hauls taken in the pond. The presence of this species, known to inhabit clean and relatively unpolluted waters, supports the findings from physico-chemical analysis that the water quality conditions in this pond are good and commensurate with the requirements of healthy and diverse biotic communities. Two *Potamogeton* species (*P. pectinatus* and *P. pusillus*) were recorded with low abundance on the bed of the pond.

(d) Macroinvertebrates

Sampling revealed the Áras Pond to have a relatively diverse macroinvertebrate community. In fact, this pond reported the highest number of taxa of all the ponds that were surveyed in the Phoenix Park (Appendix III). Sweep samples for macroinvertebrates were collected in shallow water, from the emergent vegetation stands, and in deeper water, from the floating-leaved *P. amphibium* and from the submerged macrophytes and algae.

The Freshwater louse (*Asellus aquaticus*) was the most abundant species recorded. This species has a widespread distribution in Ireland and is found in a range of freshwaters from clear streams to stagnant polluted ponds.

Plate 9. Mayfly species (*Caenis horaria)* recorded in Áras Pond, Áras an Uachtaráin, in June 2007

It occurred in large numbers amongst the emergent vegetation of the Áras Pond, together with the Common Ramshorn snail (*Planorbis planorbis*) and Non-biting midge larvae (Chironomidae spp.). The bivalve snail (*Pisidium* spp.) was recorded in considerable numbers in an area of the pond dominated by filamentous algae.

Overall, the taxa represent a range of species that have a high tolerance of organic pollution. These include crustaceans, snails, leeches and chironomids (Appendix III). However, the Áras Pond was notable in comparison to the other ponds in having a larger number of insect species including two mayfly (*Caenis horaria* (Plate 9) and *Cloeon dipterum*), three cased caddisflies (*Mystacides longicornis*, *Triaenodes bicolor* and *Phryganea bipunctata*), a dragonfly (*Aeshna* spp.) and a damselfly (*Ischnura elegans*). The caddisflies, in particular, belong to two families that are considered to have a low tolerance of pollutants (Armitage *et al.*, 1983). The diverse macroinvertebrate community in the Áras Pond most likely reflects the good water quality, together with the variety of mesohabitats that are available for colonising. Studies have demonstrated that benthic macroinvertebrates have shown a greater abundance and species diversity in macrophyte beds (Soszka, 1975) compared to more barren habitats. The greater structural complexity of macrophyte beds provides a number of benefits, including refuge from predators and a greater diversity of prey species.

(e) Fish

Only one fish species, rudd (*Scardinius erythropthalmus*), was recorded from the Áras Pond. A CPUE of 33 (Table 4) revealed an abundant, although monospecific, fish population. This represented the largest population of rudd in the Phoenix Park, and the CPUE figures recorded compare favourably with Irish lakes and ponds outside the park (Kennedy & Fitzmaurice, 1974).

The rudd captured ranged between 10-25cm in fork length and 19-396g in weight. The length frequency histogram for the rudd revealed a balanced population (Figure 4), with the majority of fish aged between 4 and 6 years of age. The oldest fish recorded was 8 years old. This specimen measured 25cm and weighed 396g. Overall, rudd were in excellent physical condition (Plate 10). A small proportion (<5%) showed visual signs of external parasitic infections. This was identified as Black spot (*Posthodiplostomulum cuticola*), a common external parasite that does not cause problems for the fish unless they are heavily infested.

Table 4. Catch Per Unit Effort (CPUE), length and weights of rudd captured during survey netting of Áras Pond, Áras an Uachtaráin, Phoenix Park, in June 2007.

	No.	CPUE	Length (cm)	Weight (g)
Rudd	66	33	17.6 10 - 25	126 19 – 396

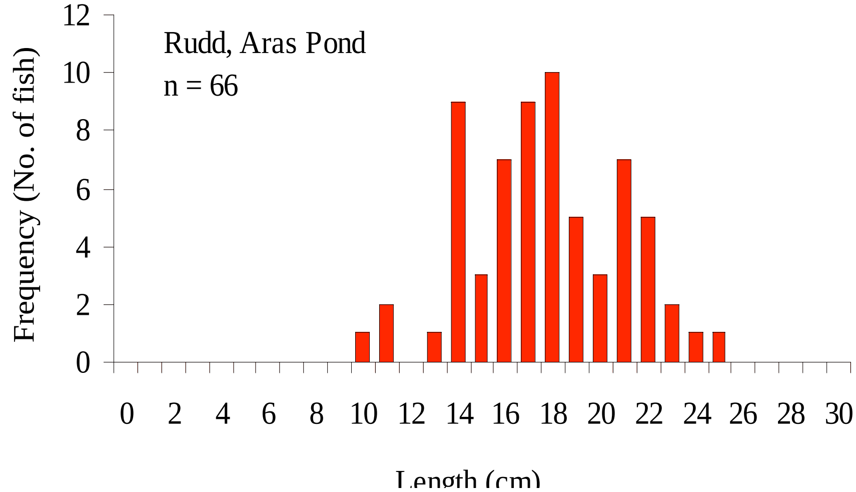

Figure 4. Length frequency distribution of rudd captured in the Áras Pond, Áras an Uachtaráin, Phoenix Park, in June 2007.

No trout were recorded from the pond during the survey, even though trout had been stocked by the CFB in the past. Given the possibility of water temperatures reaching their lethal limit of 25^{o}C for trout (Barton, 1996) in this pond, combined with the fact that no suitable spawning habitat is available in or adjacent to the pond, it is unlikely that any trout would have survived from the original stocking operations.

3.1.3. Discussion

The results from the present survey conducted in the Áras Pond indicate a healthy ecosystem with good water quality, relatively diverse plant and macroinvertebrate communities and an abundant, although monospecific fish stock. According to Dublin Zoo staff, the pond was drained in 2000 facilitate alterations to the African Plains Pond in Dublin Zoo (immediately downstream of the Áras Pond). This does not appear to have had a serious impact on the ecology of the pond, as this survey provides evidence of a successful re-colonisation by aquatic flora and fauna.

The good water quality in the Áras Pond was reflected in the biotic composition of this water body. The macroinvertebrate community included a number of caddisfly species (*Mystacides longicornis*, *Triaenodes bicolor* and *Phryganea bipunctata*) that belong to two families known to have a low tolerance of organic pollutants. The presence of the charophyte *Chara vulgaris* is also a notable find. Charophytes are primary colonisers of ponds and lakes and their presence indicates an ecologically rich and relatively healthy trophic status.

As one of the least common native/ naturalised coarse fish species in the country, the presence of a healthy population of rudd was a welcome discovery.

Plate 10. Rudd (*Scardinius erythropthalmus*) captured during survey operations in June 2007. Áras Pond, Áras an Uachtaráin, Phoenix Park.

Rudd are a prized angling species in Ireland, although locations where they are readily available for angling are in significant decline. This reflects the fact that they have been competitively excluded from many of their former habitats by the more prolific and aggressive, invasive roach (*Rutilus rutilus*) (Caffrey & McLoone, 2004). The fact that no roach have yet been introduced to the Áras Pond has probably maintained favourable conditions for the rudd. The rudd is an attractive species, with bronzed flanks and blood-red fins (Plate 10). During the warmer summer months, shoals of rudd provide a focus for onlookers as they swim at the water surface. The small infestation of black spot on the rudd that was observed during the survey presented no threat to the population in the Áras Pond. This parasite is common in rudd and it is probable that the abundance of snails (primary hosts) in the pond, along with avian predators, such as herons (final hosts) provide favourable conditions for the parasite (Kennedy & Fitzmaurice, 1974).

3.1.4. Recommendations for future management

The main priority of the Áras Pond is to provide a visual amenity on the grounds of Áras an Uachtaráin for its residents and visitors. Therefore, one objective may be to reduce the level of unsightly filamentous algae that is present in the pond at certain times of the year (Plate 11). This not only affects the aesthetic value of the pond but can result in serious diurnal fluctuations in dissolved oxygen levels (Caffrey, 1992). These fluctuations can be sufficient, particularly during warm weather, to cause fish kills. One environmentally-friendly method that has proved effective for the control of filamentous algae in freshwaters is the use of rotted barley straw (Caffrey, 1999). The rotted straw has strong anti-algal properties. It is recommended to apply the straw at a rate of $10gm^{-3}$ (Barrett & Banks, 1995; Ridge *et al.*, 1995; Caffrey, 1999) in the open water column, packed relatively loosely in garden netting to allow the straw to rot quickly and aerobically (Barret *et al*., 1996).

Plate 11. Presence of filamentous algae bloom in Áras Pond, Áras an Uachtaráin, during October 2007.

The straw should be introduced to the pond in winter, when no algae are present in the water. The straw must be replaced every 4 to 6 months, depending on the rate of decay. The removal of the filamentous algae would improve the aesthetics of the pond by increasing water clarity, as well as providing conditions that would favour the establishment of diverse plant and faunal communities. This, in turn, would provide a more diverse habitat for the fish stock within the pond, increasing the level of cover from avian predators, such as herons and cormorants, and creating spawning substrate and refuge for juvenile fish stocks.

Plate 12. Bream (*Abramis brama*)

In order to improve the fish stock diversity within the pond, it might be appropriate to augment the rudd stock with other native / naturalised coarse fish species. It would be important to use only those species that would not be antagonistic to the rudd and that would not adversely impact on the habitat. The introduction of relatively small numbers of bottom-dwelling bream (*Abramis brama*) (Plate 12) and tench (*Tinca tinca*) would improve diversity without causing any adverse ecological impact to the status of the Áras Pond.

3.2. AFRICAN PLAINS POND (No. 2 - System A)

3.2.1. Introduction

The African Plains Pond in situated in the southeast corner of the Phoenix Park, within the boundary of the Dublin Zoo complex (see Figure 1). It was part of the original 'Fish Pond' (which included the Áras Pond) until the boundary of Áras an Uachtaráin was altered in 2000 to create two separate water bodies - the Áras Pond, which remained within Áras an Uachtaráin, and the African Plains Pond, which was donated to Dublin Zoo. This is the second pond on System A (Viceregal Stream). It receives its water supply through two 15-20" pipes from the Áras Pond (Figures 5 & 6). The outflow consists of an underground culvert in the southwest corner of the pond, which discharges into the World of Primates Ponds. During the survey, in October 2007, the flow of water within the system was negligible, possibly due to the extremely dry conditions experienced at this time.

Plate 13. The African Plains Pond, Dublin Zoo, Phoenix Park.

At *circa* 2.6 hectares, the African Plains Pond is the largest water body in the Phoenix Park. It is an S-shaped on-line pond, with one island and a peninsula located at its northern end (Figure 6 and Plate 13). The latter, the chimpanzee complex, was constructed in 1997 to provide more space for the apes during daylight hours. The island is used to accommodate a mangamese monkey population, with bridged access to an indoor shelter on the eastern side of the pond.

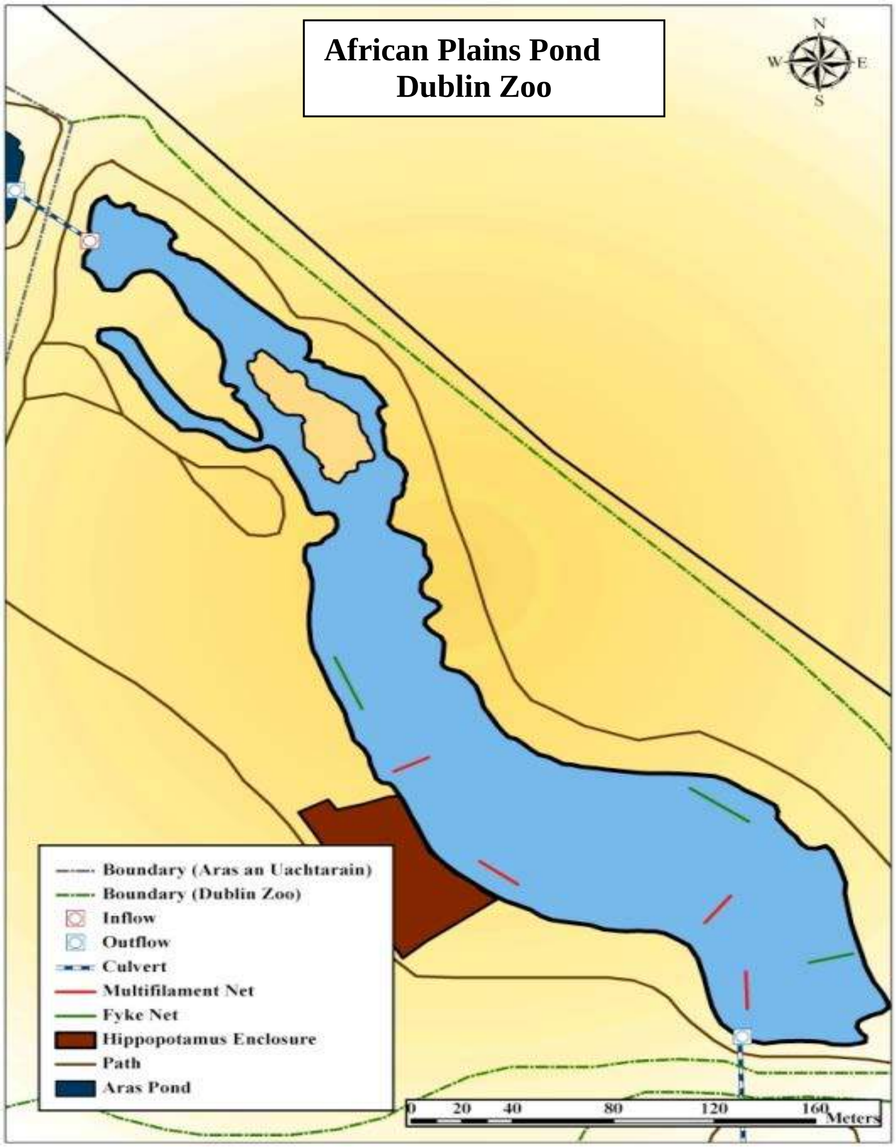

Figure 6. The African Plains Pond, Dublin Zoo, Phoenix Park.

The entire perimeter of the pond is encircled by a pedestrian walkway, providing access for patrons to all of the animal enclosures that are situated around the pond (Figures 5 and 6). Between the pond and the path, established deciduous trees and shrubs, particularly on the eastern and western banks, line the pond. These tall trees cast significant shade on the pond margins and have, over time, resulted in considerable accumulation of leaf litter and woody debris in the pond.

3.2.2. Results

(a) Bathymetry

The deepest part of the lake was 4.5m deep and was located at the southern end, in the vicinity of the outflow (Figure 7). The average depth was 1.5m. The present survey corroborated information produced by a depth survey undertaken in 2000 (Burke, 2001).

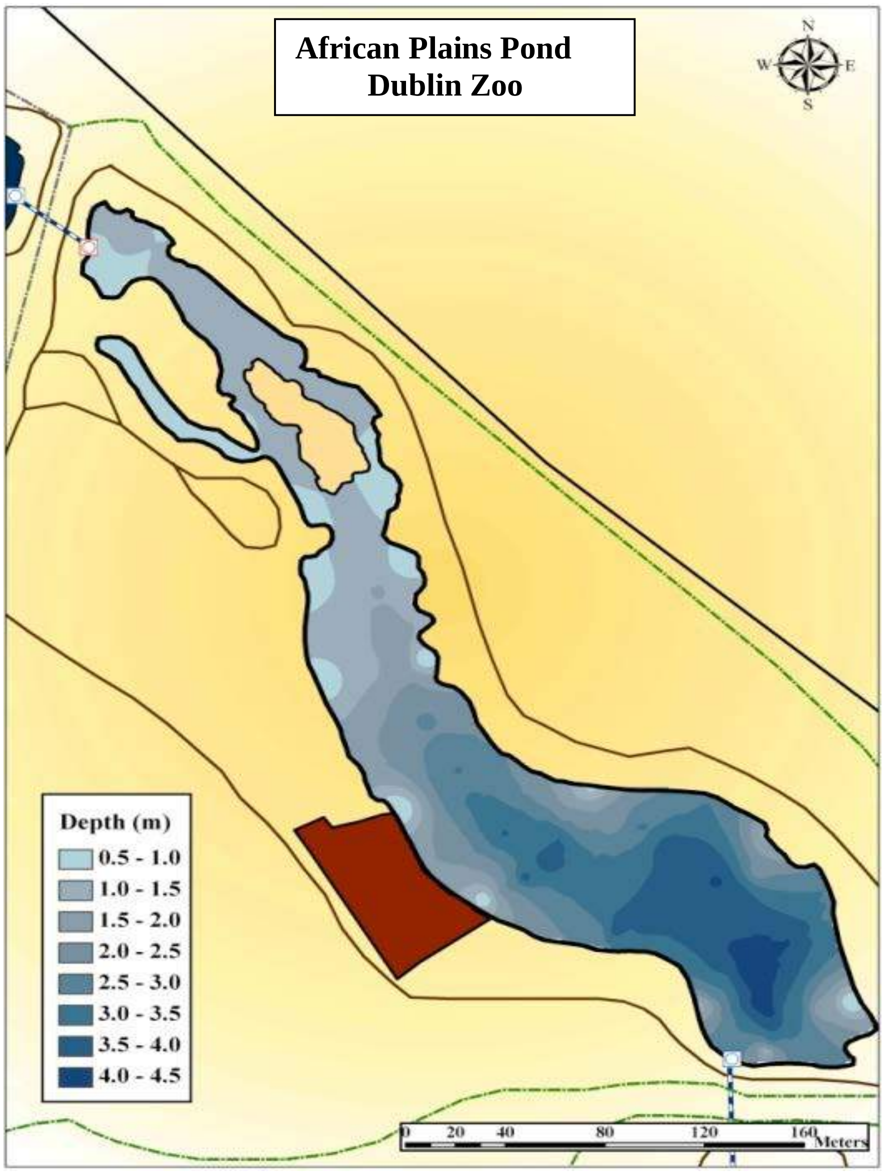

Figure 7. Bathymetric map of the African Plains Pond, Dublin Zoo, Phoenix Park.

(b) Water Quality

Water clarity at the time of sampling was excellent, with Secchi depth readings of 2.7m recorded. Chlorophyll levels were correspondingly low, indicating the pond has a mesotrophic ($<25mgl^{-1}$) status (Table 5 & Appendix I). This is in agreement with results from water analysis conducted in 2001 (Morrissey, 2001). Water temperatures reached a maximum of 16.2°C. The highest conductivity level was recorded at 547µS/cm. Total phosphorus (TP) and molybdate reactive phosphate (MRP) levels were high across the pond in October, with mean TP over twice the recommended level (0.063mg/l) and mean MRP over three times higher than the threshold value of 0.02mg/l.

Table 5. Physico-chemical data recorded from the African Plains Pond, Dublin Zoo, in October 2007. Results in red indicate breaches in parameters (see Table 1).

Sample Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/cm	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Inflow	Oct. 07	0.117	0.056	0.051	547	2.15	14.134	700	126	16.1
Mid-lake	Oct. 07	0.155	0.089	0.066	510	2.1	20.898	4719	82	16.2
Outflow	Oct. 07	0.151	0.079	0.066	535	2.1	28.805	5100	170	15.9

High levels of phosphorus could adversely affect the ecology of the pond by promoting algal blooms that, in the worst case scenario, could lead to a depletion in dissolved oxygen levels. The high phosphorus content is most likely generated from within the pond and could result from a number of factors. These include internal loading from accumulated sediments, decaying leaf matter, and bird and animal faeces. Bacteriological testing of water from the African Plains Pond revealed low counts for faecal coliforms and relatively high numbers for total coliforms (Table 5). A slight breach of TC (5100/100ml) occurred at the outflow.

(c) Macrophytes

The pond is surrounded by a diversity of tall trees and shrubs. These dominate the marginal areas of the pond's eastern and western shores, particularly at its southern end. Shading was estimated at over 20% in total and over 80% in most marginal areas. Reedmace (*Typha latifolia)* was the dominant reed, although Branched bureed

(*Sparganium erectum)* and Yellow flag (*Iris pseudacorus)* were frequently recorded. These tall marginal plant species normally formed monodominant stands and rarely entered into mixed assemblage. It is considered that significantly more abundant stands would occupy these pond margins if the level of bankside shading was reduced.

Polygonum amphibium was the principle floating-leaved macrophyte species recorded in the pond. This species presented localised but dense floating rafts of vegetation, primarily in the channel adjacent to the newly created chimpanzee peninsula (Plate 14a).

Plate 14. Marginal and floating-leaved aquatic plant communities on a) the northern and b) the southern shore of the African Plains Pond in Dublin Zoo.

The submerged macrophyte community was poorly represented in this pond. Small patches of *Callitriche* sp. (cf. *hermaphrodtica*) were present. Filamentous green algae dominated the submerged flora and there was a notable lack of vegetation present given the excellent water clarity. The absence of submerged vegetation in the mid and lower section of the pond probably reflects the greater water depth in this area (Figure 6). The low abundance and diversity of submerged macrophytes recorded in the remainder of the pond could have resulted because of physical disturbance by waterfowl and/or periodic algal bloom events. The latter are likely to occur during the summer months when higher water temperatures and high levels of phosphorus combine to stimulate rapid growth of planktonic and filamentous algae. The impact of shading along the margins may also be a contributory factor.

(d) Macroinvertebrates

The African Plains Pond supported a relatively high number of macroinvertebrate taxa, although numbers of individuals were low (Appendix III). Samples were collected in the sheltered marginal areas that were dominated by the emergent Reedmace (*Typha latifolia*) and from the exposed sediments in the shallow pond areas. The invertebrate fauna consisted, for the most part, of crustaceans, water boatmen, snails and leeches. These all belong to families that have a high tolerance of organic enrichment. The Freshwater louse (*Asellus aquaticus*) and the water boatman (Corixidae sp.) were the most abundant species and these were recorded in their highest numbers amongst the emergent flora.

Plate 15. The Freshwater louse (*Asellus aquaticus*) recorded from the African Plains Pond, Dublin Zoo, in October 2007.

Water boatmen are a type of water bug common in ponds, lakes and slow-moving water courses, usually with abundant plant life. One species of mayfly (*Cloeon dipterum*) and a single caseless caddisfly (*Holocentropus picicornis*) were encountered while sampling this pond. The Pond Olive (*C. dipterum)* was recorded in the majority of ponds in Phoenix Park; however, it attained its highest numbers in the African Plains Pond. It is common and widespread in Ireland and its nymph can be found in a range of standing waters including ponds, streams and canals. The nymphs of *C. dipterum* are often associated with small productive water bodies, which may explain their widespread occurrence in the Phoenix Park ponds. *Holocentropus picicornis* belongs to a family of caddisfly (Polycentropodidae) whose larvae spin silken nets to catch prey. *Holocentropus* nets are usually attached to vegetation and consist of sheet-like or funnel-shaped structures with tubular retreats for the larvae.

(e) Fish

Only one fish species, rudd (*Scardinius erythropthalmus*), was recorded from the African Plains Pond. A CPUE of 2.25 (Table 6) revealed a small monospecific fish population. The rudd captured ranged between 20-32cm in fork length and 135-727g in weight.

Table 6. Catch Per Unit Effort (CPUE), length and weights of rudd captured during survey netting of African Plains Pond in June 2007.

	No.	CPUE	Length (cm)	Weight (g)
Rudd	9	2.25	23.3 (20-32)	727 (135-727)

The length frequency histogram for the rudd revealed an unbalanced population (Figure 8), with all fish captured being 20cm or over in length and ranging from 6-8 years of age. The oldest fish recorded was 10+ years old. This specimen measured 32cm and weighed 727g (Plate 16). While low in numbers, the rudd present in this pond were in good physical condition.

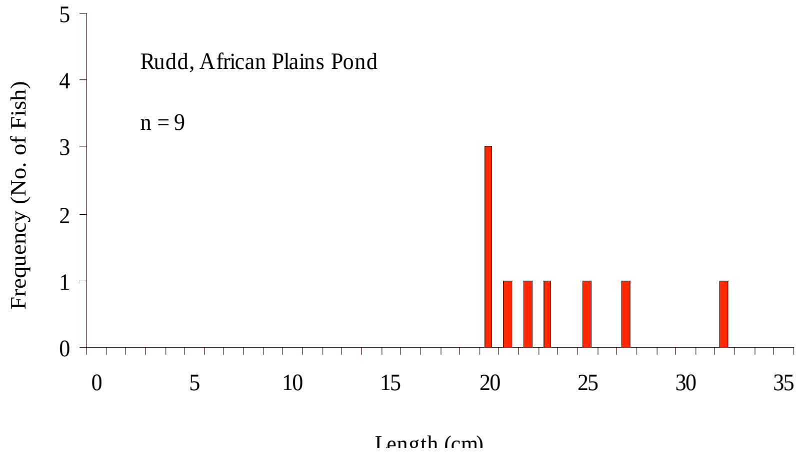

Figure 8. Length frequency distribution of rudd captured in the African Plains Pond, Dublin Zoo, Phoenix Park in June 2007.

Plate 16. Rudd (*Scardinius erythropthalmus*) from the African Plains Pond, Dublin Zoo, in October 2007.

It had been reported by Dublin Zoo staff, and others, that common carp (*Cyprinius carpio*) were present in the African Plains Pond. No carp were observed or captured during the survey. Nor have any recent reports of carp sightings been recorded. It is probable that the large carp reputedly present in this pond were spawn-bound, thus producing no progeny to recruit to the population. As a consequence, the aged population of carp probably died off. It is also the case that carp can be notoriously difficult to capture using traditional fish capture techniques. Seine netting is a favoured method to target this species. However, the sheer volume of woody debris on the pond floor rendered the successful operation of this technique impossible.

3.2.3. Discussion

Results from the survey conducted in the African Plains Pond indicate enriched conditions, with moderately high levels of the nutrient phosphorus in the water. Overall, the macrophyte, macroinvertebrate and fish communities are lacking in diversity and abundance. While water samples were collected on one occasion only, in October, results are comparable with seasonal data recorded in 2000 (Morrisey, 2001), indicating that a similar water quality status has persisted over this time period.

The shading effect of trees and shrubs along the margins has undoubtedly restricted the growth of littoral submerged and emergent macrophytes. The paucity of the marginal vegetation may explain the relatively low numbers of benthic invertebrates that were recorded, as studies have shown that macroinvertebrates have a greater diversity and biomass in habitats with a high structural complexity (e.g. Soszka, 1975; Dvorac & Best, 1982). The lack of aquatic plants in the littoral zone may also have had an effect on the recruitment of rudd in the pond, as they require plant substrate on which to spawn and for nursery purposes. Only large rudd (>20cm) were captured and there was no evidence of juvenile fish. It is possible that the rudd are able to move between this and the Áras Pond, through the large inlet pipes at the northern end of the African Plains Pond. By doing this, they may have evaded detection during the survey.

3.2.4. Recommendations for future management

The majority of artificial waters require the intervention of man to replenish reducing stocks of fish. It is apparent that there is a lack of suitable recruitment habitat to sustain a large population of rudd. The majority of rudd probably originated from the Áras Pond, with adult fish moving down to the African Plains Pond. Every effort should be made to create favourable habitat conditions for this prized coarse fish species in the pond, although it is accepted that, currently, nutrient levels in the water may pose an obstacle to successful population recruitment and development. The establishment of a moderately abundant submerged flora in the pond would automatically improve conditions for fish, while also competing with unsightly algae for nutrients. This situation could be aided by reducing the level of bankside shading and/or transplanting suitable macrophyte species to the pond.

Consideration should be given to reintroducing common carp to the African Plains Pond. Carp are long-lived fish that can grow to 40+lb under favourable conditions. They are also tolerant of enriched and even polluted water conditions. Even during warm weather, when dissolved oxygen falls to levels that are lethal for most other fish species, carp will commonly survive. An additional bonus is that carp show at the water surface during warm weather and would, therefore, provide an additional spectacle for Zoo visitors.

The CFB had been requested to assess the ecological impact of extending the hippopotamus enclosure into the pond (Figure 6), giving them access to the water. At the present time, measures are in place to avoid the input of excess nutrients from the animal enclosures that encircle the pond. An extension of this enclosure would involve dredging the pond and using the dredged spoil to develop a reed-bed at the lower end of the lake, which would act as a nutrient sink. However, the water in the African Plains Pond is already prone to high phosphorus loading. The potential for the waste produced by these animals exacerbate the already poor water quality conditions is considerable.

3.3. WORLD OF PRIMATES POND (Upper & Lower) *(No. 3 - System A)*

3.3.1. Introduction

A. Upper World of Primates Pond

The third pond in System A is known as the Upper World of Primates Pond. A small, rectangular-shaped pond, it is situated downstream of the African Plains Pond (see Figure 1) and within the Dublin Zoo complex. It is connected *via* the Viceregal Stream to the African Plains Pond through an underground culvert, which enters at its northern end (Figure 9). It is directly linked to the larger Lower World of Primates Pond through a 10m-long and 3m-wide open channel at its southern end (Figure 9). This channel is crossed by a bridge, which incorporates a pedestrian path for zoo patrons. Water flow was negligible during the survey, possibly due to the extremely dry conditions experienced in October 2007. A large volume of leaf litter was evident on the pond floor.

At *circa* 2500m^2, the Upper World of Primates Pond is the smallest water body in the entire park system. It contains three small islands, and the banks are formed by a concrete apron.

Plate 17. Upper World of Primates Pond, Dublin Zoo, Phoenix Park.

The pond is bordered by a metal perimeter fence (0.4m in height) and is situated in one of the busiest areas of the park. Paths leading to the sea lion centre, on its western side and a path, which crosses the channel between both World of Primate Ponds towards the elephant centre, encircles the pond. Trees and shrubs populate the banks. A shop and seating facility is located to the east of the pond at a small clearing. The pond acts as a water supply to the elephant enclosure, which is situated to the east of the pond, through a 4-6” pipe that is laid out 3-4m into the water (Figure 9).

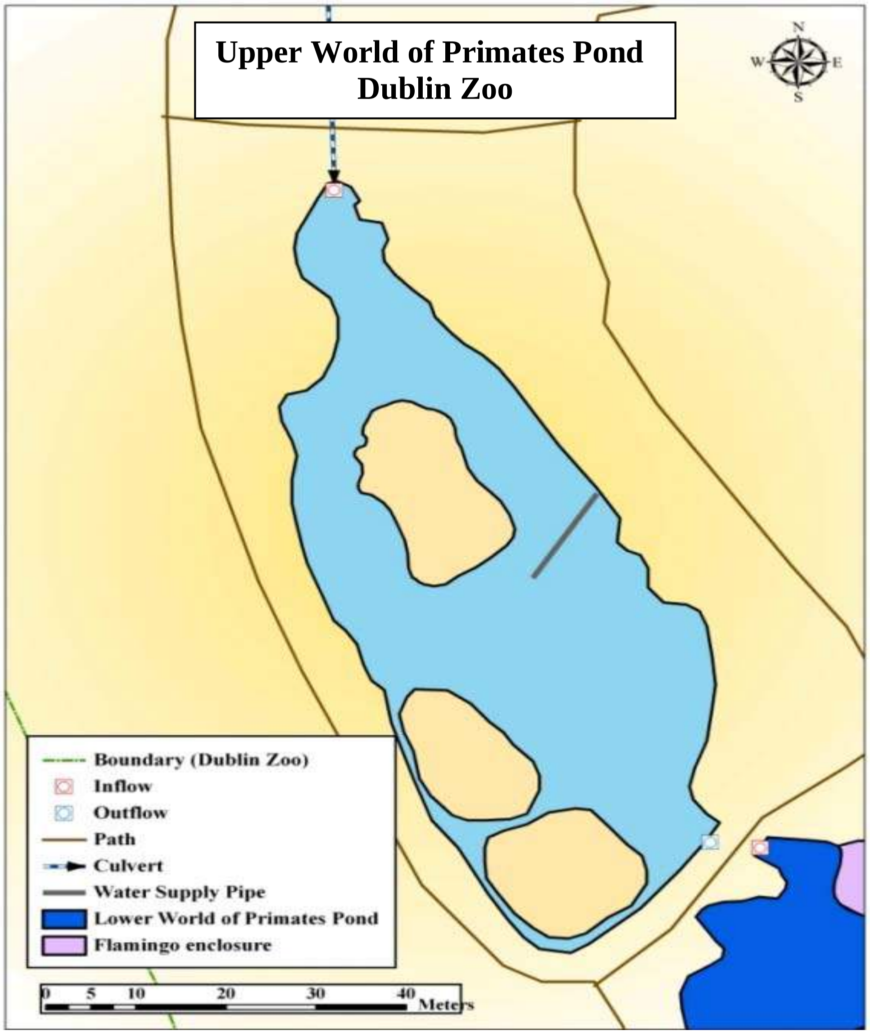

Figure 9. Map showing shape and design of the Upper World of Primates Pond in Dublin Zoo, Phoenix Park.

B. Lower World of Primates Pond

The Lower World of Primates Pond is entirely within the Dublin Zoo complex. It receives its water supply from the Upper World of Primates Pond through a 10m-long channel at its northern end (Figure 10). The outflow pipe carries water from this pond, out of the Dublin Zoo complex, and down to the People’s Garden Pond.

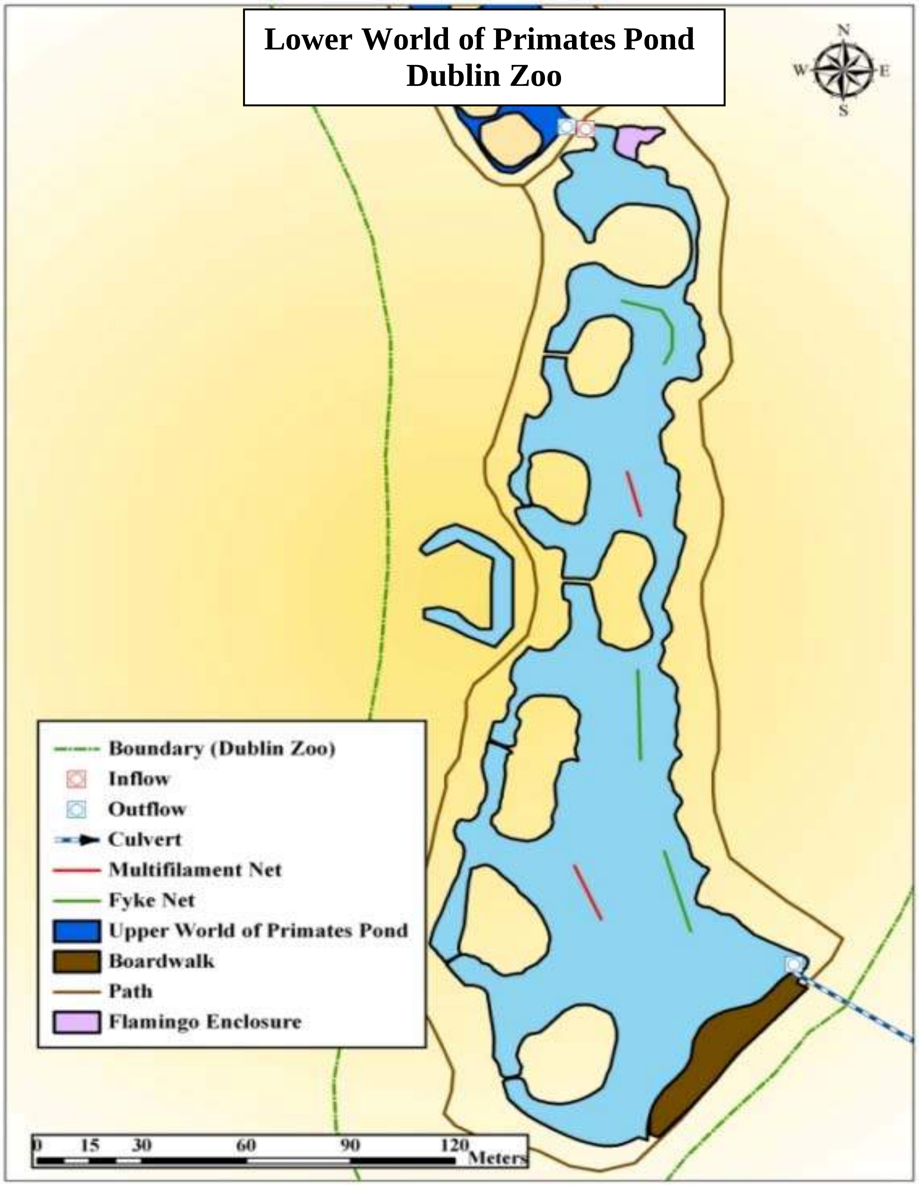

Figure 10. Map showing shape and design of the Lower World of Primates Pond in Dublin Zoo, Phoenix Park.

The pond has been a part of the Zoological Gardens since its inception in 1831. It has undergone major modifications since 1997 when, in order to house a number of primate species, a series of islands and an artificial peninsula (Figure 10) were constructed. A large rectangular-shaped water, it now occupies an area of *circa* 1.2 hectares.

Plate 18. A view of the Lower World of Primates Pond in Dublin Zoo from the boardwalk, looking towards the northern end of the pond.

The Lower World of Primates Pond is situated in a small valley, with natural slopes (up to 60m high on its eastern and western shores). The main buildings of the Dublin Zoo overlook the pond on its eastern bank, while several large enclosures are located on the sloping bank on its western side. The pond has been incorporated into the main entrance building through a boardwalk that runs along its southern bank (Plate 19, Figure 10). The relatively narrow northern end of the pond is home to a resident flamingo population (Figure 10).

The entire pond is encircled by walkways (Figure 10). These lead to and from the main entrance, the animal enclosures and the seating areas. Between the paths and the pond, the eastern and northern banks are dominated by large trees, which overhang the banks of the pond. The western shore is lined by indoor primate enclosures. These are connected to the four islands *via* walkways for the primate's daily use.

Plate 19. The Lower World of Primates Pond, Dublin Zoo. The Boardwalk at the entrance to the Dublin Zoo can be observed to the left.

The islands were constructed with large boulder perimeters to protect their banks from erosion (Plate 20a). The problems of bank erosion were in evidence at the flamingo nesting site during the survey (Plate 20b, Figure 10).

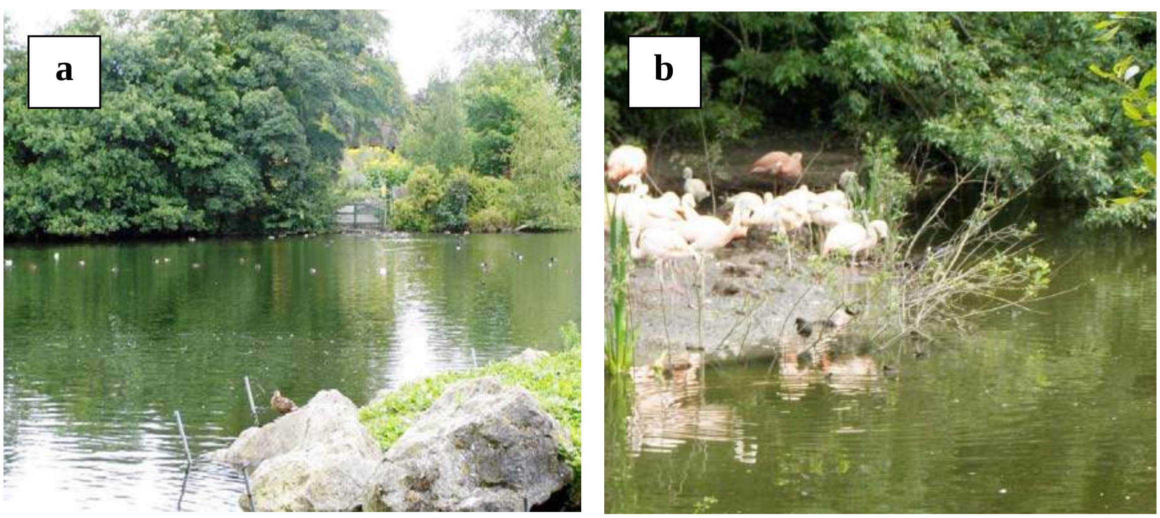

Plate 20. The Lower World of Primates Pond showing a) bank protection on one of the islands and b) erosion of banks by flamingo population, with measures in place to encourage marginal plant growth.

According to Dublin Zoo staff, efforts are being made to counteract the bank subsidence through infilling with earth and the introduction of willow saplings.

3.3.2. Results

(a) Bathymetry

(I) Upper World of Primates Pond

The upper World of Primates Pond is a very shallow on-line water, with a maximum depth of 1m (Figure 11). The mean depth at the time of the survey was 0.6m.

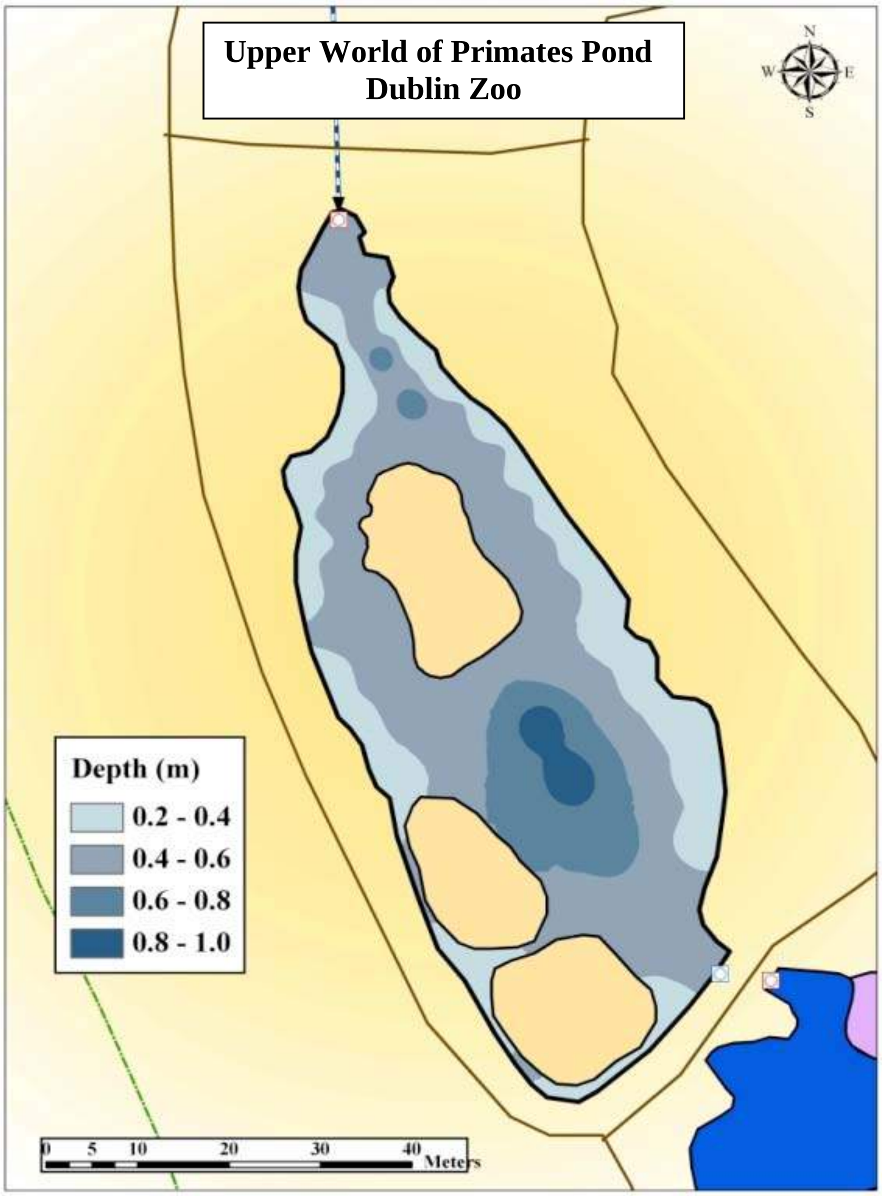

Figure 11. Bathymetric map for Upper World of Primates Pond in Dublin Zoo, Phoenix Park.

(II) Lower World of Primates Pond

Water depths ranged between 0.4 and 4.4m, with the deepest section at the southern end of the pond (Figure 12). The mean depth was 2m.

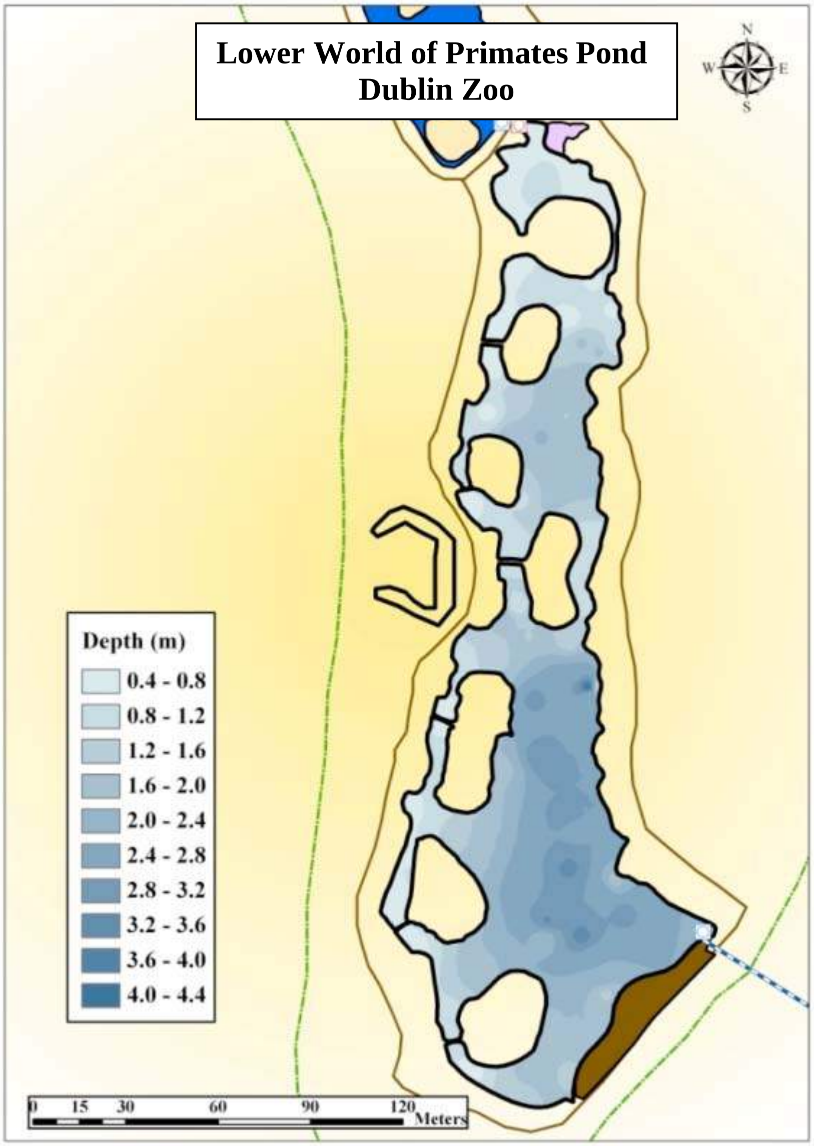

Figure 12. Bathymetric map for Lower World of Primates Pond in Dublin Zoo, Phoenix Park.

(b) Water Quality

Analysis of water samples taken in October 2007 from the Upper and Lower World of Primate Ponds revealed poor water quality conditions, with serious breaches in a number of parameters including TP, MRP, chlorophyll, TC and FC (see Table 7 & Appendix I). At the time of sampling, the water was extremely turbid, with a dense phytoplankton bloom giving the pond a deep green colour (Plate 21). Secchi disc readings of less than 10cm were recorded throughout the pond. The maximum water temperature recorded was 16.3^{o}C. The highest conductivity value was measured at 531µS/cm. The phytoplankton bloom in the lower pond in October resulted in excessively high chlorophyll levels, reaching a maximum of 248.3mg/l. This level of chlorophyll in the water would lead to a categorisation of the pond as hypertrophic (>75mg/l chlorophyll *a*) at the time of sampling (see Appendix I). Results from the nutrient analyses showed both ponds to be extremely enriched, with TP and MRP values breaching the guideline limits at all sampling points. Values of TP as high as 0.614mg/l were recorded in the Lower World of Primates Pond. This is almost ten times higher than the recommended limit of 0.063mg/l. MRP values reached 0.542mg/l in the lower pond. This is approximately 25 times over the threshold value of 0.02mg/l.

Table 7. Physico-chemical data recorded from the Upper and Lower World of Primates Ponds, Dublin Zoo, During 2007. Results in red indicate breaches in parameters (see Table 1).

Sample	Date	Total P	MRP	TON	Cond.	Alk.	Cphyll a	Total bacteria No.	Faecal bacteria No.	ºC
UPPER		mg/l	mg/l	mg/l	µS/cm	meq/l	µg/l	100ml	100ml	
Inflow	Oct.07	0.294	0.145	0.214	523	3.91	2.565	4989	544	15.7
Mid-lake	Oct.07	0.367	0.295	<0.049	512	4.3	107.073	12859	8785	16
Outflow	Oct.07	0.479	0.396	<0.049	531	4.1	130.826	28260	13734	16

Sample	Date	Total P	MRP	TON	Cond.	Alk.	Cphyll a	Total bacteria No.	Faecal bacteria No.	ºC
LOWER		mg/l	mg/l	mg/l	µS/cm	meq/l	µg/l	100ml	100ml	
Inflow	Oct.07	0.614	0.456	<0.049	502	3.91	248.319	48380	48380	16.3
Mid-lake	Oct.07	0.606	0.542	<0.049	499	4.11	228.621	12122	8560	16.2
Outflow	Oct.07	0.578	0.482	0.06	512	4.6	183.055	1962	544	16.2

A number of factors probably contributed to the highly elevated phosphorus levels, including sediment release and sewage runoff from the primate islands. However, the flamingo enclosure, located at the western end of the lower pond, is undoubtedly the most significant contributor to the enriched status of this pond. High levels of both TP (0.614 mg/l) and MRP (0.456 mg/l) were recorded close to this enclosure, indicating that flamingo excrement is increasing the high levels of phosphorus that is already present in the water column. This finding is underpinned by results of the coliform analysis, with extremely high counts (>48,000/100ml) of total and faecal coliforms obtained from a water sample taken adjacent to the flamingo enclosure. Coliform counts in excess of the threshold values were recorded in the lower section of the Upper World of Primates Pond and extended to the Lower World of Primates Pond, east of the flamingo enclosure.

Plate 21. Lower World of Primates Pond, Dublin Zoo, Phoenix Park in October 2007. The extent of the algae bloom can be clearly seen.

Results of water quality analysis on the Upper and Lower World of Primate Ponds revealed highly eutrophic conditions. The flamingo enclosure is contributing to significant nutrient loading, the outcome of which was visually apparent in the dense phytoplankton bloom in the lower pond at the time of sampling. This eutrophic state has significant repercussions for the overall ecology of the pond and its ability to sustain healthy floral and faunal communities, in addition to the impact on the aesthetic appeal of the water body.

(c) Macrophytes

The margin areas in the World of Primates Ponds are not very conucive to the establishment and growth of a healthy macrophyte flora. In places, the banks are exposed and boulder-strewn while, elsewhere, they are overgrown with tall bushes, shubs and decidous trees. These relatively inhospitable conditions, combined with a highly turbid and excessively nutrient-enriched water, resulted in the reduced macrophyte community present in these ponds (see Appendix II). Where space was available and sufficient light penetrated, small stands of Yellow flag (*Iris pseudacorus*) and lesser clumps of Unbranched burreed (*Sparganium erectum*) and Reed sweet-grass (*Glyceria maxima*) were present. These emergent species commonly occupied very localised and often isolated stands and did little to benefit the aquatic macroinvertebrate or fish fauna in the pond. The floating-leaved and submerged flora was highly restricted, primarily as a consequence of the dense, light-occluding algae blooms that persist on this highly enriched watercourse. The principal submerged species was the Blanketweed, *Cladophora glomerata* (Appendix II). Even this pollution and shade tolerant algal species struggled in the turbid water that occupied these ponds.

(d) Macroinvertebrates

Both the Upper and Lower World of Primate Ponds were characterised by a poor macroinvertebrate fauna, comprised mainly of crustaceans (*Asellus aquaticus* and the shrimp *Crangonyx pseudogracilis,* Plate 22*)*, leeches (e.g. *Helobdella stagnalis*), chironomids and oligochaete worms (Appendix III). Sampling in the upper pond was carried out on the exposed sediments of the shallows. The littoral zone of the Lower World of Primates Pond consisted of large rocks and boulders and this made sweep net sampling difficult.

Plate 22. *Crangonyx pseudogracilis* in the Upper and Lower World of Primates Ponds in Dublin Zoo during October 2007.

The paucity of the macroinvertebrate community in the Upper and Lower World of Primates Ponds was not surprising given the poor water quality and the nature of the physical environment, which was lacking in habitat structural diversity. The majority of taxa recorded belonged to families that are considered to have a high tolerance of organic pollution, reflecting the eutrophic condition of this water body. Molluscs, which are an important constituent of the macroinvertebrate communities in most ponds, were virtually absent here. Caddisflies were also absent from both the Upper and Lower World of Primates Ponds and only a single species of mayfly (*Cloeon dipterum*) was recorded, in low abundance (see Appendix III).

(e) Fish

(I) Upper World of Primates Pond

A small population of perch (*Perca fluviatilis*) was captured in the Upper World of Primates Pond in October 2007. This small monospecific population ranged from 14-19cm in fork length and 36-106g in weight (Table 8 & Figure 13). There was a definite imbalance in the age structure of the population, with probably only two age classes present. These were represented by perch in the size ranges – 14cm and 17-19cm. The lack of young or old perch suggests that conditions in the pond do not favour the proliferation of the species. This imbalance in the fish population probably reflects the poor water quality conditions and the impact that this has on living and recruitment conditions for these fish.

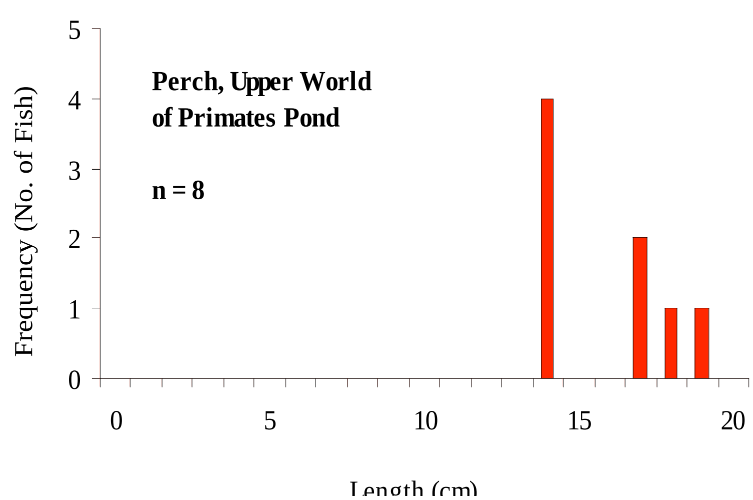

Figure 13. Length frequencies distribution of perch captured in the Upper World of Primates Pond in Dublin Zoo, Phoenix Park, in October 2007.

The shallow water in this small pond made netting difficult and all of the fish were captured using electrofishing equipment.

Table 8. Catch Per Unit Effort (CPUE), length and weight of perch captured during electrofishing operations undertaken in the Upper World of Primates Pond in October 2007.

	No.	CPUE	Length (cm)	Weight (g)
Perch	8	-	16 14-19	70 36-106

(II) Lower World of Primates Pond

Four fish species were recorded in the Lower World of Primates Pond. These were perch, rudd, tench and eels. Survey data revealed that perch were the single largest component of the fish population (81%) in this pond (Figure 15). A high CPUE of 31 for perch was recorded, although the population appears to be limited one dominant year class, in the 17-18cm range (Table 9 & Figure 14).

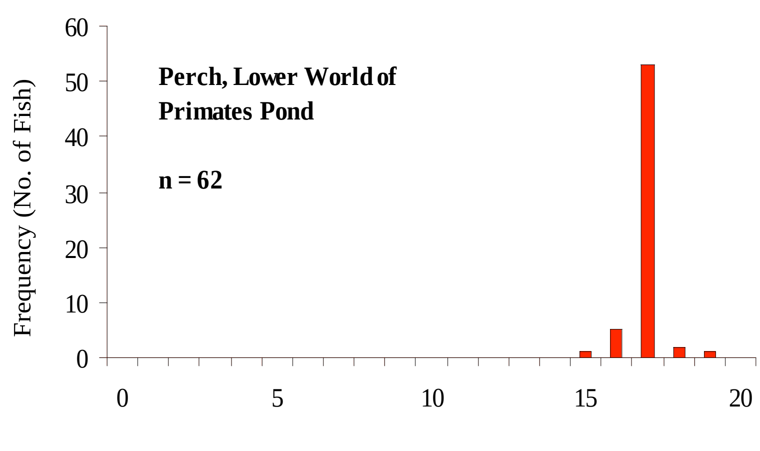

Figure 14. Length frequencies distribution of perch captured in the Lower World of Primates Pond in Dublin Zoo, Phoenix Park, in October 2007.

No perch less than 15cm was captured or observed during the survey. Weights ranged between 57 and128g (Table 9).

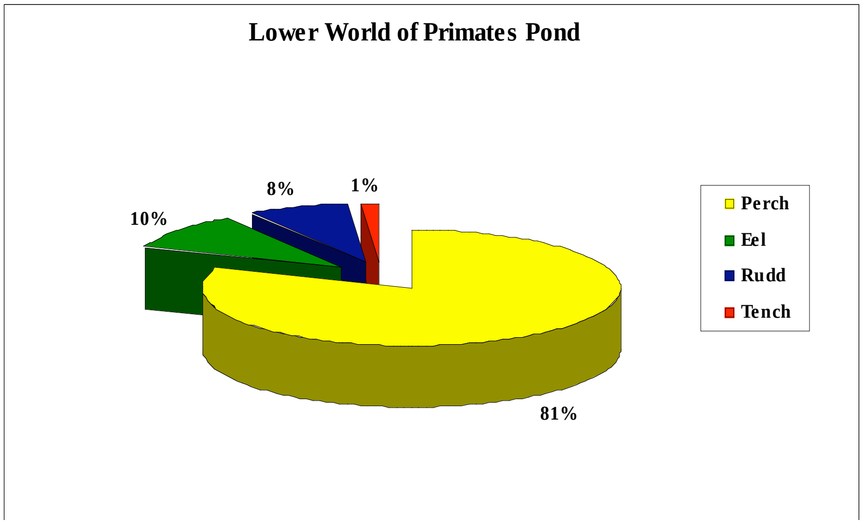

Figure 15. Relative representation of each fish species captured in the Lower World of Primates Pond in October 2007.

Eels (*Anguilla anguilla*) were the second largest component of the population, at 10% (Figure 15). Eels are benthivorous or bottom living fishes and are rarely captured in gill nets. Fyke netting (see Table 2) is the preferred sampling method for this species.

Plate 23. Specimen eel (2.02kg) captured in the Lower World of Primates Pond, Dublin Zoo, during netting in October 2007.

Of the eight eels captured during the fyke netting operation, the largest recorded was 95cm in length and 2.02kg in weight (Plate 23). This is a very large fish and exceeds the current Irish specimen fish weight of 1.361kg (ISFC, 2007).

Table 9. Catch Per Unit Effort (CPUE), mean length and weights of fish species captured during survey netting of Lower World of Primates Pond in October 2007.

Species	No.	CPUE	Length (cm)	Weight (g)
Perch	62	31	17 15-19	73.1 57-128
Eel	8	-	95 45-95	- (max - 2002)
Rudd	4	2	19.75 17-23	174.5 136-210
Tench	1	-	17.6	96

A small population of rudd was also recorded. These fish ranged from 17-23 cm in fork length and 136-210g in weight (Table 9). A single small tench (*Tinca tinca*), with a length of 17cm and weighing 96g, was recorded during the fyke netting operation (Table 8). Age analysis revealed this fish to be 3+ years old, displaying normal growth rates when compared to tench in other ponds throughout the Phoenix Park.

Carp (*Cyprinius carpio*) are believed to be present in the Lower World of Primates Pond, according to Dublin Zoo staff. No carp were recorded or observed during the survey in October 2007.

3.3.4. Discussion

The World of Primates Ponds are a classic example of a eutrophic water body, where abiotic factors and biotic interactions have created the unfavourable habitat conditions that were apparent at the time of sampling. Water quality analysis showed that the ponds supported highly elevated levels of phosphorus (both TP and MRP) and that these were augmented by faecal contamination from the flamingo enclosure, located at the top of the

Lower World of Primates Pond. Increased phosphorus loading led to an increase in primary producers and this explains the dense phytoplankton bloom that was in evidence at the time of sampling. Low rainfall and bright sunshine in October 2007 obviously created optimum conditions for algae production. Higher rainfall might have increased the flow velocity through the ponds and may have flushed out some of the nutrients that had accumulated. From discussions with Dublin Zoo personnel, it is apparent that these dense phytoplankton blooms have become a regular feature of this water body.

Dense algal blooms lead to an increase in the amount of organic detritus that accumulates on the sediment surface. Bacterial decomposition of this detritus increases oxygen consumption in the water body and can result in fish kills. However, eutrophication processes can also create conditions that favour an increase in the numbers of cyprinid fishes and a dominance of a particular year class. The population of perch in the Lower World of Primates Pond appears to corroborate this. European studies have shown that perch have the potential to impact significantly on the ecology of the systems into which they have been introduced, directly influencing zooplankton, macroinvertebrate and fish populations (Persson & Greenberg 1990, Tonn *et al.,* 1992; Persson & Eklöv, 1995). Depending on habitat conditions, the lifecycle of a perch includes a planktivorous (feeding on zooplankton) and piscivorous (feeding on fish) phase, with juvenile fish usually representing the planktivorous stage. Length frequency analysis of perch in the Lower World of Primates Pond shows dominant age cohorts between 15 and 19cm, representing juvenile fish, which most likely survive on a diet of zooplankton. Indeed, results from stomach analysis of some of the captured perch revealed significant numbers of zooplankton in these fish. In eutrophic conditions, perch can exacerbate the problem of algal blooms that already exist as a result of high nutrient loading. They prey on large zooplankton, such as the cladoceran Water Flea (*Daphnia)*, which graze on algae. This leads to reduced numbers of these species and an increase in the numbers of smaller, less efficient grazers, such as *Bosmina* (Persson *et al*., 1988). While zooplankton species were not investigated in this survey, a cursory examination of a water sample from the Lower World of Primates Pond revealed very high numbers of *Bosmina* sp., suggesting that the perch population may be having an impact on the dynamic equilibrium in the ponds (Brooks & Dodson, 1965).

In summary, the Upper and Lower World of Primates Ponds are highly eutrophic water bodies, displaying the classic symptoms of the interplay between abiotic factors and biotic interactions under these conditions.

3.3.4. Recommendations for future management

Future management of the World of Primate Ponds would ideally involve removing the sources of phosphorus enrichment coming from the flamingo enclosure and restoring the pond to a healthier, less productive state. In the late 1990s, a ring sewer was installed in response to the gross pollution that was occurring in the Lower World of Primates Pond (Burke, 2001). This feature does not appear to have had any positive affect on water quality in the pond, however. Undoubtedly, the flamingos provide a major asset to the Dublin Zoo and relocating them may not be feasible, as it would only create problems elsewhere. However, consideration should be given to containing or diverting the effluent problem that these ornate birds represent.

Mechanisms are available for the restoration of ponds, although these can be costly. Biomanipulation, a term first introduced in the mid-1970s (Shapiro *et al.*, 1975), refers to the manipulation of biota to improve water quality, specifically by reducing algal blooms in eutrophic lakes. Biomanipulation generally involves reducing the abundance of zooplanktivorous fish (in this case, perch), either by addition of piscivorous fish, such as pike (*Esox lucius*), or by manually removing the undesired fish species. In theory, the removal of a sufficient number of planktivorous fish should decrease predation pressure on large zooplankton and the grazing rate on algae will increase.

In the Lower World of Primates Pond a deep, anoxic and highly-nutrient rich mud carpets the bed. Nutrient exchange between the silt and water ensures that there is always sufficient growth-promoting nutrients available for phytoplanktonic growth. Removal of a large fraction of this mud will reduce the nutrient component that is available for planktonic growth, while also creating a healthier and more ecologically sustainable habitat for resident biotic communities. Dredging may be conducted in the traditional manner, where the pond must be dried out and the silt removed using heavy plant machinery, or using an innovative method where the minimum of habitat disturbance is caused. This latter method involves using a sweep-back slurry-type pump, on a raft, to remove the mud from the pond and pump it into large geotextile tubes, which are situated on the bank side. Over a period of weeks, the water drains through the geotextile lining to leave relatively dry silt that may be used for other purposes elsewhere in the park.

An immediate priority would be to combat the unsightly algal blooms that are a feature of this pond and that have such a negative on the biological communities and the overall functioning of the water body. Elimination or moderation of the algal bloom would increase water clarity and allow the establishment of aquatic floral and faunal communities. Once aquatic macrophytes establish, they would help to remove nutrients from the water column, while also providing a refuge for zooplankton communities against fish predation.

Plate 24. Common carp (*Cyprinus carpio*)

In order to immediately tackle the problem, while considering a more long-term solution, barley straw could be introduced into the ponds. Rotted straw has the ability to control filamentous and planktonic algae growth through its anti-algal properties (Caffrey, 1999). It is recommended that barley straw be introduced at a rate of 10g m^{-3} or 100 kg $acre^{-1}$, according to the method described in Caffrey (1999). The straw will not remove nutrient from the water column but will help reduce the visual manifestation of the nutrients (i.e. algal blooms).

An increase in marginal vegetation would enhance the diversity of the ponds as well as protecting exposed banks from further erosion. Current efforts are being made by Zoo staff to deal with the erosion taking place at the flamingo enclosure. These include infilling eroded areas and planting willow saplings at the exposed edges of the pond (Plate 20b). Additional protection could be achieved by inserting staked willow bunches (or faggotts) 1 to 1.5m out from the water's edge, beyond the willow saplings (O' Grady, 2006). Bankside recolonisation might also be expedited by transplanting live rhizomes from a range of reed species into the pond margins (Caffrey & Beglin, 1996). Reedmace rhizomes from the Dog Pond in the Phoenix Park could be used to start this operation.

To improve fish stock abundance and diversity in the ponds, it would be worthwhile to reintroduce a small number of common carp to these water bodies. Carp will thrive under the conditions that are present in these ponds. They will provide an added attraction for spectators due to their basking behaviour during the summer months and they should be capable of producing a self-sustaining population. As carp are tolerant of eutrophic water conditions, they will thrive under the conditions present in these ponds. A stocking with *circa* 100kg of young carp (1+ and 2+ years old) will provide a significant population of large carp in future years.

3.4 PEOPLE'S GARDEN POND *(No. 4 - System A)*

3.4.1. Introduction

Created as part of the famous People's Garden in 1864 (OPW, 1993), this is one of the larger ponds in the Phoenix Park, occupying an area of *circa* 0.8 hectares. It is fed entirely by the discharge from the Lower World of Primates Pond in the Dublin Zoo complex. The pond is located in a deep depression known as the "hollow" (Davenport & Hughes, 2004) in the south-eastern corner of the Phoenix Park (Plate 25, see Figure 1). This is the fifth and last pond on the Viceregal Stream that passes through the Áras Pond and through the three ponds located within Dublin Zoo. From the People's Garden Pond the water discharges into the River Liffey, some 1.2 km to the south (Figure 16). The pond is situated in a busy section of the park, between the Islandbridge and North Circular Road entrances (see Figure 1).

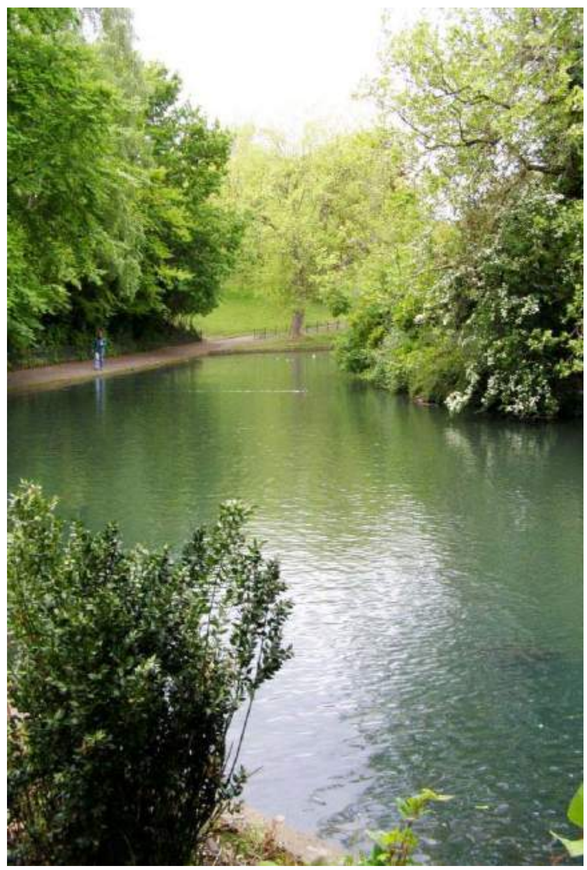

Plate 25. Views of the upper section of the People's Garden Pond in the Phoenix Park.

The pond has two sections, a larger upper and a smaller lower pond (Figure 16). The latter simply represents an expanded outflow channel, with a concrete bed and sides. This small pond is tree-lined on its southern bank and bordered by a pathway on its northern bank. It is densely shaded by the overhanging tree canopy and this contributes to a deep layer of leaf litter on the pond floor. The perimeter is entirely concrete based and supports practically no marginal plant growth. A bridge separates the upper from the lower sections.

Plate 26. The (a) upper and (b) lower sections of the People's Garden Pond, Phoenix Park.

The margins of the upper section are largely natural and are densely reed fringed (Plate 26 a). The reed beds add character to the pond and provide a myriad of habitat niches for waterfowl and other wildlife. The perimeter at the eastern end of this pond, in the vicinity of the island, is a concrete structure and supports practically no marginal flora.

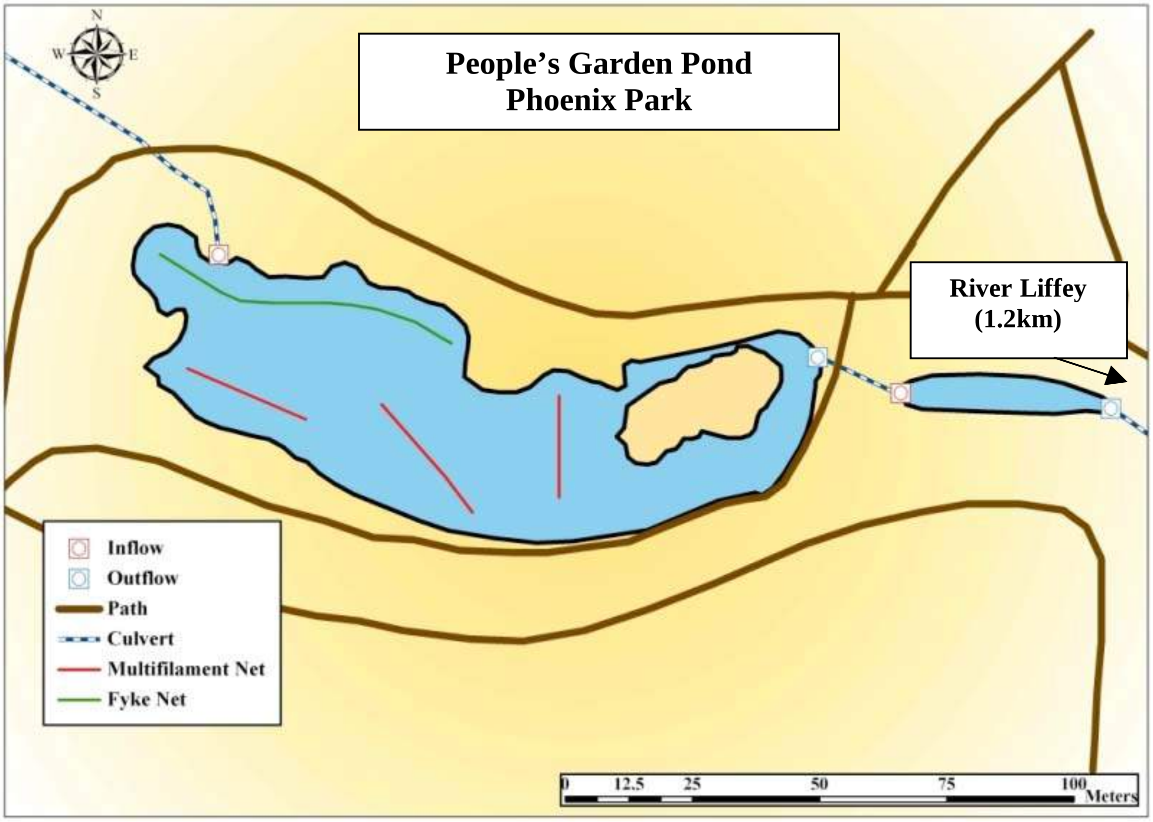

Figure 16. Map showing the upper and lower sections of the People's Garden Pond in the Phoenix Park.

3.4.2. Results

(a) Bathymetry

Water depths in the upper section of the People's Garden Pond ranged between 0.4 and 2m when surveyed in June 2007. The deepest section, at 2m deep, was at the eastern end of the pond, adjacent to the island. The mean depth was 0.8m (Figure 17). The lower section of the pond had a mean depth of 0.5m and had a maximum depth of 0.6m.

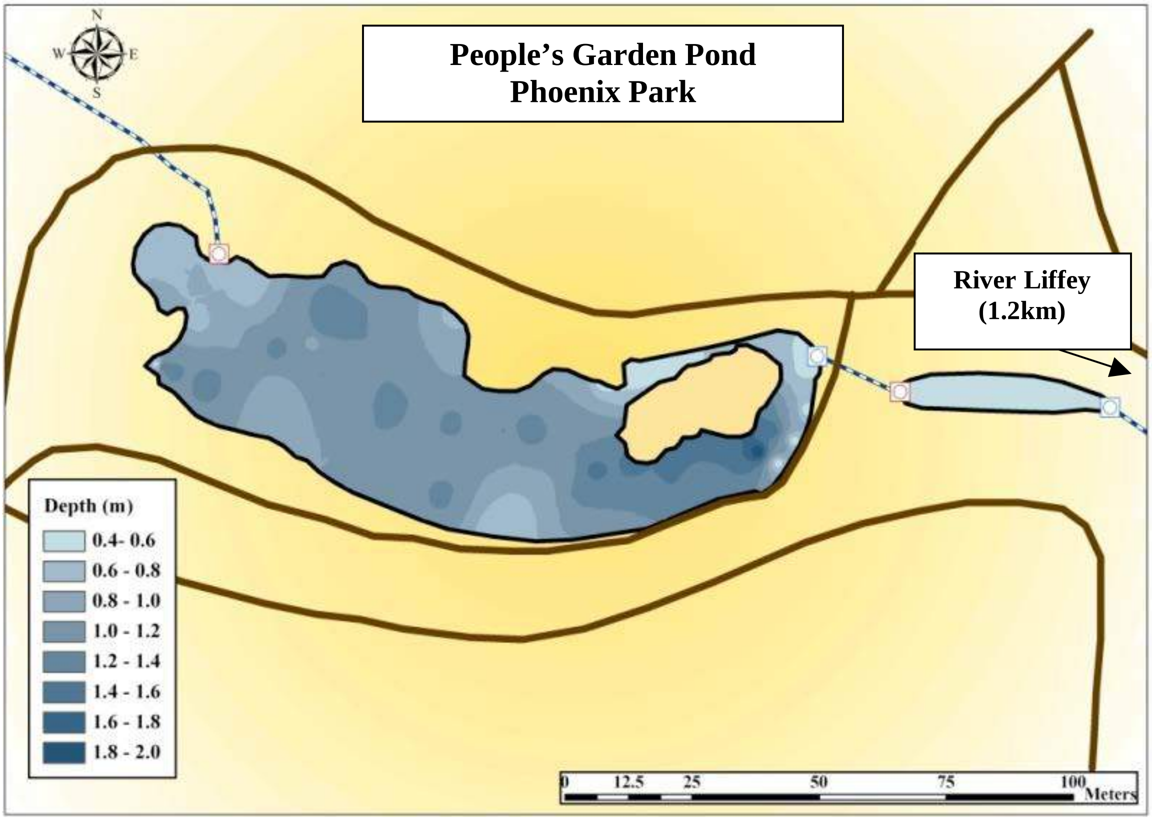

Figure 17. Bathymetric profile of the upper and lower sections of the People's Garden Pond, Phoenix Park in June 2007.

(b) Water quality

Secchi disc readings of 2m, the maximum depth recorded in the pond, were recorded in the upper section of the pond on both sampling occasions. However, a minor algal bloom was in evidence during the October survey. Water temperatures ranged from a high of 19.1^{o}C in June to 15.3^{o}C in October (Table 10 & Appendix I). Conductivity values ranged from 335μS/cm in October to 390μS/cm in June, while Alkalinity levels varied between 4.0 and 4.7meq/l, indicating an alkaline and hard water.

Nutrient analysis revealed elevated readings for both TP and MRP across the pond on both occasions, with TP recorded at a maximum of 1.099mg/l (threshold 0.063mg/l) in October and MRP peaking at 0.165mg/l (threshold 0.02mg/l) in June. A number of factors are likely to have contributed to the nutrient enrichment in this pond, including phosphorus release from sediments, bird faeces and food introduced to the pond as bird feed. The People's Pond provides a habitat for a sizeable waterfowl population that includes coot, moorhen, mallard and swan. By defecating in the pond, these birds contribute significantly to the phosphorus levels already available in the water. The main source of phosphorus, however, is likely to originate from the Lower World of Primates Pond in the Dublin Zoo complex, which feeds directly into the People's Garden Pond. The water in the Lower World of Primates Pond was extremely enriched when sampled in October (see Section 3.3.2) and this is undoubtedly impinging on water quality in this receiving water.

Table 10. Physico-chemical data recorded from the People's Garden Pond during 2007. Results in red indicate breaches in parameters (see Table 1).

Peoples Garden Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	°C
Inflow	June 07	0.192	0.114	0.398	381	4.6	12.056	1780	480	19.1
Mid - lake	June 07	0.069	0.042	<0.049	390	4.06	4.023	1640	370	19.1
Outflow	June 07	0.169	0.165	0.134	381	4.46	3.374	1580	290	19.1
Inflow	Oct. 07	1.099	0.153	0.09	340	4.67	56.6	1400	178	15.6
Outflow	Oct. 07	0.345	0.093	<0.049	335	4.73	24.2	980	150	15.3

Chlorophyll results showed an elevated level of 56µg/l at the inflow in October (Table 8). Eutrophic conditions in the Lower World of Primates Pond had resulted in a dense phytoplankton bloom in that watercourse in October and this obviously carried through to this pond, as evidenced by the high reading recorded. Bacteriological results show compliance with the standards and, despite the large number of waterfowl, the total and faecal coliform counts were below threshold levels (Table 10).

Water quality in the People's Garden Pond reflects its position at the lower end of the system of ponds that begins with the Áras Pond, on the grounds of Áras an Uachtaráin. High levels of phosphorus are mostly attributed to the influence of receiving waters from the highly enriched Lower World of Primates Pond in the Dublin Zoo complex.

(c) Macrophytes

The marginal zone in the upper section of the People's Garden Pond was dominated by tall, virtually continuous stands of Common reed (*Phragmites australis*). This tall reed occupied *circa* 70% of the marginal area in this pond and dense stands extended up to 5m into the water, often to a depth of 1.5m (Plate 27). Occasional, small stands of Sedge (*Carex* spp.) were present in marginal zones where *Phragmites* stands had been removed or disturbed. Small stands of the floating-leaved Yellow water-lily (*Nuphar lutea*) were present in the upper pond. It is probable that these stands will expand to occupy significantly more surface cover, if the pond remains undisturbed. The free floating species Common duckweed (*Lemna minor*) and Ivy-leaved duckweed (*L. trisulca*) were present with low abundance in the upper pond.

Plate 27. Marginal vegetation communities, dominated by *Phragmites australis*, in the upper section of the People's Garden Pond, Phoenix Park, in June 2007.

Plate 28. Dense submerged *Elodea canadensis* and free floating *Lemna minor* in the lower section of the People's Garden Pond, Phoenix Park, in June 2007.

The most abundant submerged macrophyte in the pond was Canadian pondweed (*Elodea Canadensis*), a plant that is tolerant of nutrient-rich conditions and thrives in waters that receive periodic disturbance. Its abundant vegetative expression here might reflect the occasional dredging or pond maintenance that this watercourse has been subjected to in recent years.

Another pollution tolerant species present in the pond was Blanketweed (*Cladophora* sp. (cf. *glomerata*)). This green filamentous alga created a thin carpet over the muddy substrate and over the *Elodea* stands, but never threatened to smother the latter. Small, straggling stands of Stonewort (*Chara vulgaris*) were recorded in the vicinity of the island. The presence of this species in such a nutrient-rich system was unexpected. Thin strands of Lesser pondweed (*Potamogeton pusillus*) were present in the upper section of the pond. These occasionally rose to the surface to create a thin canopy layer. A thin covering of the filamentous green alga Blanketweed (*Cladophora* sp. (cf. *glomerata*)) was present in the pond.

In the small, lower pond, *E. canadensis* dominated the aquatic flora, occupying *circa* 70% bottom cover. In places, this dense vegetation was carpeted with lush green stands of the free-floating Common duckweed (*Lemna minor*).

(d) Macroinvertebrates

Sampling of the People's Garden Pond was carried out in the variety of mesohabitats that were present in this water body. A large number of taxa were recorded, with very high numbers of crustaceans, molluscs, leeches and chironomids (Appendix III). *Asellus aquaticus* was the numerical dominant in the area of the pond that was dominated by filamentous algae. This mesohabitat had the largest number of individuals, with particularly high numbers of the leech (*Helobdella stagnalis*) and the bivalve (*Sphaerium* sp.). *Helobdella stagnalis* is one of the commonest leeches in freshwater and it is found in almost all types of watercourse.

Plate 29. Cased caddis (*Mystacides longicornis*) from People's Garden Pond, Phoenix Park, in June 2007.

It is usually more abundant on macrophytes than on stones and is often the most abundant leech in eutrophic lakes and ponds. It feeds on a number of prey species including chironomids, mayflies, oligochaetes and *A. aquaticus*. A greater diversity of taxa was observed in reed-fringed marginal areas of the pond. Juveniles of the gastropod snails *Bithynia tentaculata* and *B. leachii* were in high abundance here, together with *A. aquaticus*. Only two insect species were observed in this pond, the mayfly (*Cloeon dipterum*) and the cased caddis (*Mystacides longicornis*; Plate 28). These were recorded in low numbers.

(d) Fish

Five fish species were recorded in the upper section of the People's Garden Pond. Fish sampling was confined to the upper pond (see Figure 16) as there was insufficient space in the lower pond to set either gill or fyke nets. Three multimesh nets and one set of fyke nets effectively sampled the area of water available in the upper section (Figure 16). Tench were abundant and were the most numerous species recorded in the pond, comprising 45% of the total number of fish captured (Figure 18).

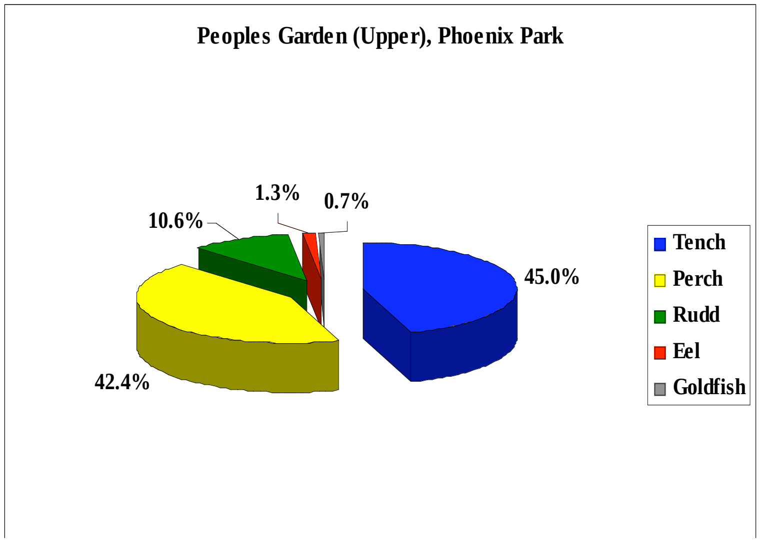

Figure 18. Relative representation of each fish species captured in the People's Garden Pond in June 2007.

The majority of tench were captured in fyke nets and, for this reason, it was not possible to calculate a CPUE value for the species. The fish ranged from 8-43cm in fork length and 8-1447g in weight (Table 11, Plate 30). The length frequency distribution for the tench revealed a balanced population, with fish spanning all of the age groups, from juvenile to 11+ years old. A number of strong year classes of fish were evident, notably those in the 3+ (8-10cm), 5 to 7+ (15 to 24cm), 8 to 9+ (28-30cm) and 9+ (>37cm) year classes (Figure 19). This balanced population indicates that the fish are thriving in the pond, with a strong YOY (Young of Year) class emerging every two to three years.

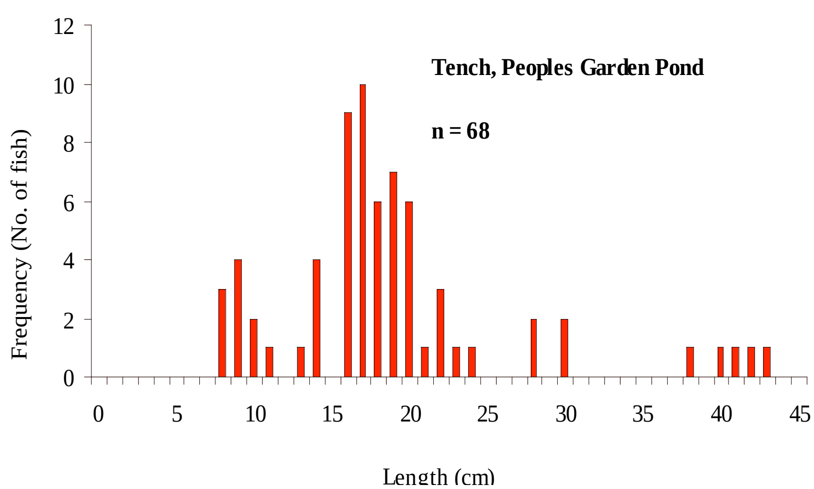

Figure 19. Length frequency distribution of tench captured in the People's Garden Pond, Phoenix Park, in June 2007.

Table 11. Catch Per Unit Effort (CPUE), mean length and weights of species captured during survey of People's Garden Pond in June 2007.

Species	No.	CPUE	Length (cm)	Weight (g)
Tench	68		18.9 8-43	176.4 8-1447
Perch	64	21.30	14.0 9-17	50.0 13-104
Rudd	16	5.30	19.8 8-22	104.0 11-240
Eel	2		85.0 84-86	1230.0
Goldfish	1		17	155

Plate 30. Tench (1.44kg) captured during electro-fishing operations on the People's Garden Pond, Phoenix Park, in June 2007.

Perch were also numerous and comprised the second largest community in the pond (42.4%) (Figure 18). They ranged from 9-17cm in length and 13-104g in weight. The length frequency data indicates two strong year classes, with peaks in the 9-11cm and 14-15cm size range (Figure 20). During electrofishing operations, large numbers of 0+ and juvenile perch were observed among the marginal vegetation. These fish were too small to effectively sample in either the multimesh or fyke nets. All of the perch captured were in good physical condition. The presence of large numbers of young perch, combined with a good stock of older fish, suggests the presence of a sustainable population in the pond.

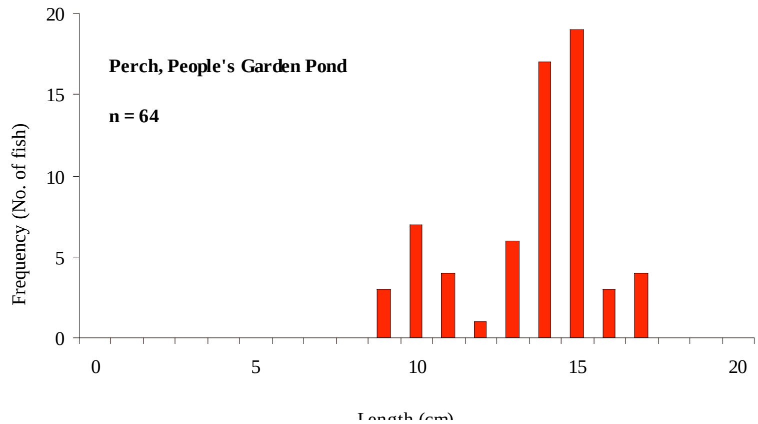

Figure 20. Length frequency distribution of perch captured in the People's Garden Pond, Phoenix Park, in June 2007.

A relatively small population (10.6%) of rudd was present in the People's Garden Pond (Figure 18). These fish ranged from 8-22cm in length and 11-240g in weight. Two distinct age cohorts, in 8-10 and16-22cm ranges, were present (Figure 21). These corresponded to rudd aged 3+ and 5 to 7+ years old, respectively.

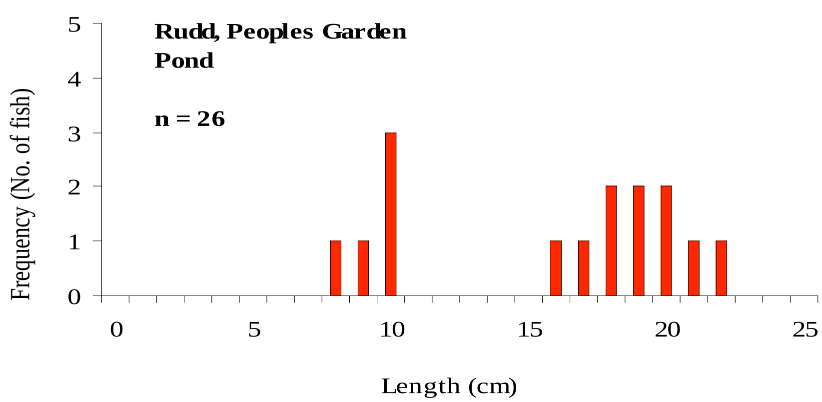

Figure 21. Length frequency distribution of rudd captured in the People's Garden Pond, Phoenix Park, in June 2007.

No juvenile rudd were captured while electrofishing, although it is possible that recently spawned fry would have been too small to see on this sampling occasion. Rudd normally spawn in May. Two eels were captured in fyke nets during the survey. The largest recorded was 85cm in length and weighed 1.2kg (Plate 31a). The presence of eels in this pond is no surprise, given the direct link from the Viceregal Stream to the River Liffey, 1.2km to the south.

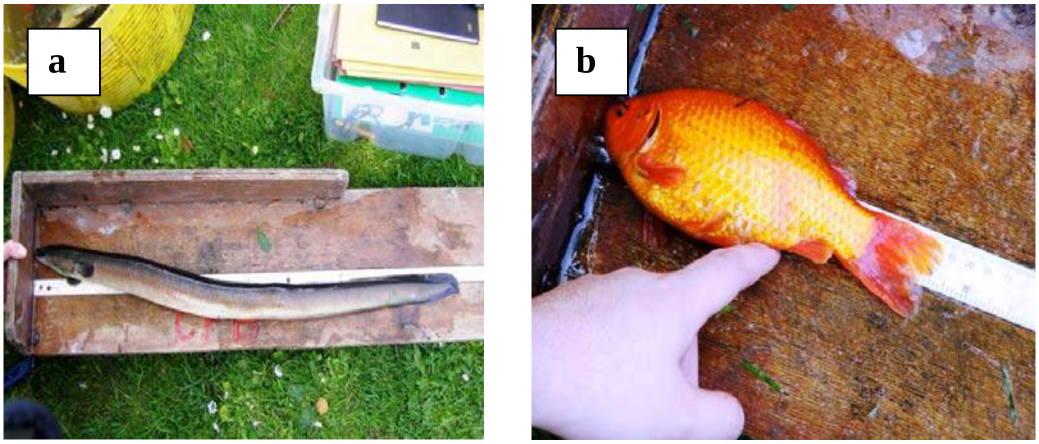

Plate 31. a) Eel (85cm, 1.2kg) and b) goldfish (17cm, 155cm) recorded in the People's Garden Pond, Phoenix Park, in June 2007.

An interesting discovery in the pond was that of a Common Goldfish (*Carassius auratus*), measuring 17cm in length and 155g in weight (Plate 31b). It is probable that this non-native fish had been purposely introduced to the pond, having grown too big for an artificial aquarium or garden pond. This fish was in excellent condition and exhibited no signs of stress or dietary deficiency.

3.4.3. Discussion

Water quality analysis of the People's Garden Pond revealed that it is susceptible to sporadic nutrient loading from the highly eutrophic Lower World of Primates Pond, located directly upstream. Elevated levels of phosphorus recorded during both surveys and the presence of a phytoplankton bloom in October were attributed, for the most part, to the influence of receiving waters from this source. The enriched status of the People's Garden Pond was reflected in the composition of its benthic macroinvertebrate communities. These were characterised by high numbers of crustaceans, molluscs, leeches and chironomid larvae and a lack of pollution sensitive insect species.

Despite the influx of excessive nutrients to the People's Garden Pond, it is likely that the flushing capacity of this pond has prevented a serious deterioration in water quality. While the quality of the water undoubtedly fluctuates over time, the current investigation has found that the pond supports a reasonably healthy and diverse flora and fauna. Extensive reed beds (mainly *Phragmites australis*) provide nesting areas and refuge for waterfowl species such as coot, moorhen and mallard. Large numbers of benthic macroinvertebrates were also recorded in these reed beds and these, in turn, provide a source of food for the fish populations. Indeed, electro-fishing operations revealed numerous juvenile tench amongst the reeds, together with large shoals of 0+ perch. It is probable that these reed beds also remove a proportion of the excess nutrients that enter the pond.

The People's Garden Pond supported the largest and most diverse fish community of all the ponds surveyed, with resident stocks of rudd, tench and perch. The presence of a healthy population of tench is particularly notable. These bottom-dwelling, benthic-feeding species are renowned amongst anglers for their hard fighting qualities (Caffrey, 2001) and their presence here is an asset to this pond. Further investigations, involving length frequency analyses, showed that the fish populations appear to be balanced and self-sustaining, with successful recruitment occurring at least every few years. The thriving fish population is a reflection of the many positive attributes of this pond, including refuge and cover, spawning and nursery habitat and the provision of adequate food supplies.

3.4.4. Recommendations for future management

With its location near the eastern entrance to Phoenix Park and its proximity to the Dublin Zoo, the People's Garden Pond is an important amenity and focal point for visitors to this section of the park. While the water in this pond has a high nutrient content, it is possible that nutrients are being flushed through the system, preventing any serious deterioration in water quality and enabling the pond to sustain a reasonably healthy biota. The People's Garden Pond has a good biodiversity and it is visually appealing with its stands of reed beds and its thriving bird population. With its diverse fish community, and particularly with the presence of tench, there is potential for the People's Garden Pond to be used to augment fish stocks in other ponds throughout the park.

3.5. DOG POND (No. 5 - System B)

3.5.1. Introduction

The Dog Pond, also known as the Citadel Pond, is situated in the southeast section of the Phoenix Park (see Figure 1). It is located to the west of Chesterfield Avenue, the main road that cuts through the park (Plate 32), and is situated to the east of the Phoenix Park cricket grounds and pavilion. Approximately 0.4 hectares in size, this pond is roughly rectangular in shape.

Plate 32. A view of the Dog Pond, Phoenix Park, from the western shore. Traffic on Chesterfield Avenue can be seen in the background.

The pond is enclosed by a metal railing, with an entrance on the north-western corner. Access is available to the general public and a pathway borders the entire perimeter of the pond (Figure 22).

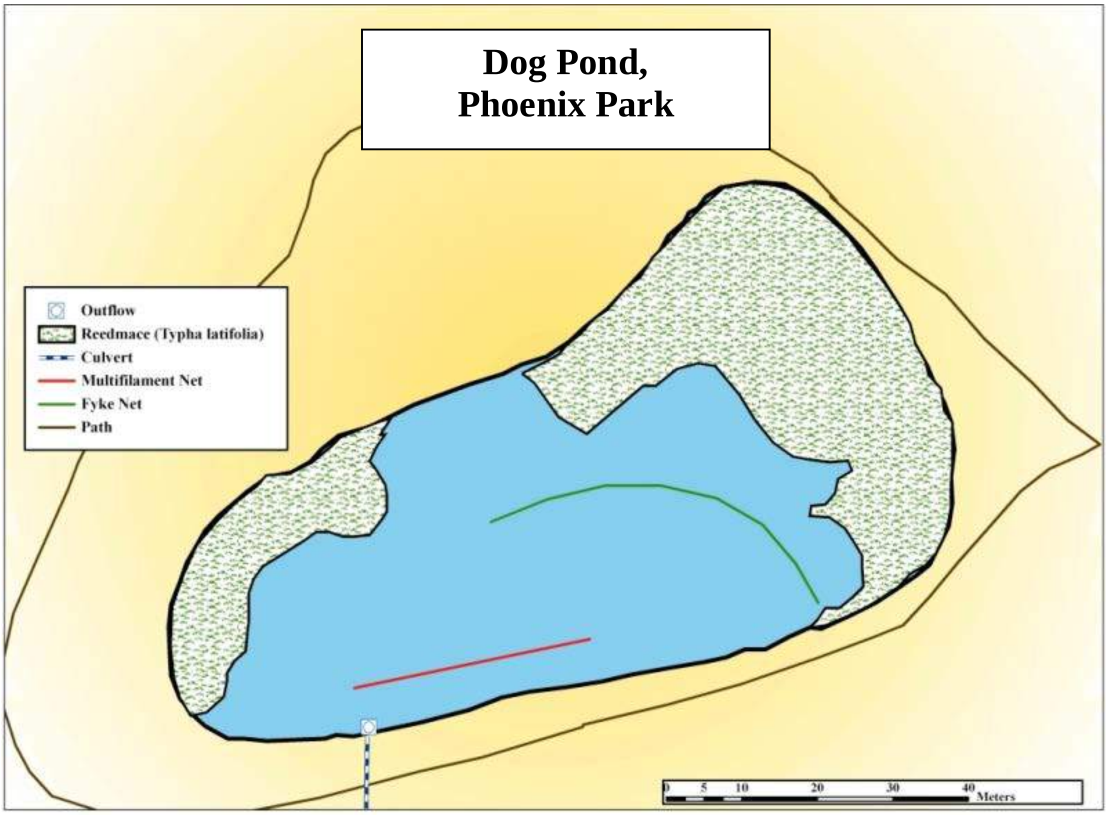

Figure 22. The Dog Pond, Phoenix Park

Plate 33. Constructed "monk" outflow on the Dog Pond, Phoenix Park.

No water inflow to the Dog Pond was located during the survey. Nor was reference made to an inflow stream or culvert in the available literature. An outflow "monk" is present at the south-western end of the pond (Plate 33). At the time of the survey, the water level was below the overflow spill.

The Dog Pond currently provides an amenity for the public in the Phoenix Park. Large numbers of walkers use the path that circumnavigates the pond, as do bird watchers and wildlife enthusiasts. Reference was made to the pond as a recreational venue for children using "sailing boats and other children's pastimes" in Dáil Éireann, as part of an open debate on the amenities present in the Phoenix Park (28th of May 1974, http://historical–debates.oireachtas.ie). Interest was expressed in developing the Dog Pond as a recreational fishery during this period. Historical records indicate that a survey was undertaken by the IFT (Inland Fisheries Trust) in September 1974 to investigate the fish stock status of the pond and to review its potential for fishery development. Following recommendations from this report, 200 common carp were introduced in 1976 (IFT, 1979). No subsequent, officially approved, fish stockings have been conducted since that date.

3.5.2. Results

(a) Bathymetry

The Dog Pond is a shallow pond, which supported a maximum depth of 1m when the survey was undertaken in June 2007 (Figure 23). The mean water depth in the open water of the pond at this time was 0.5m.

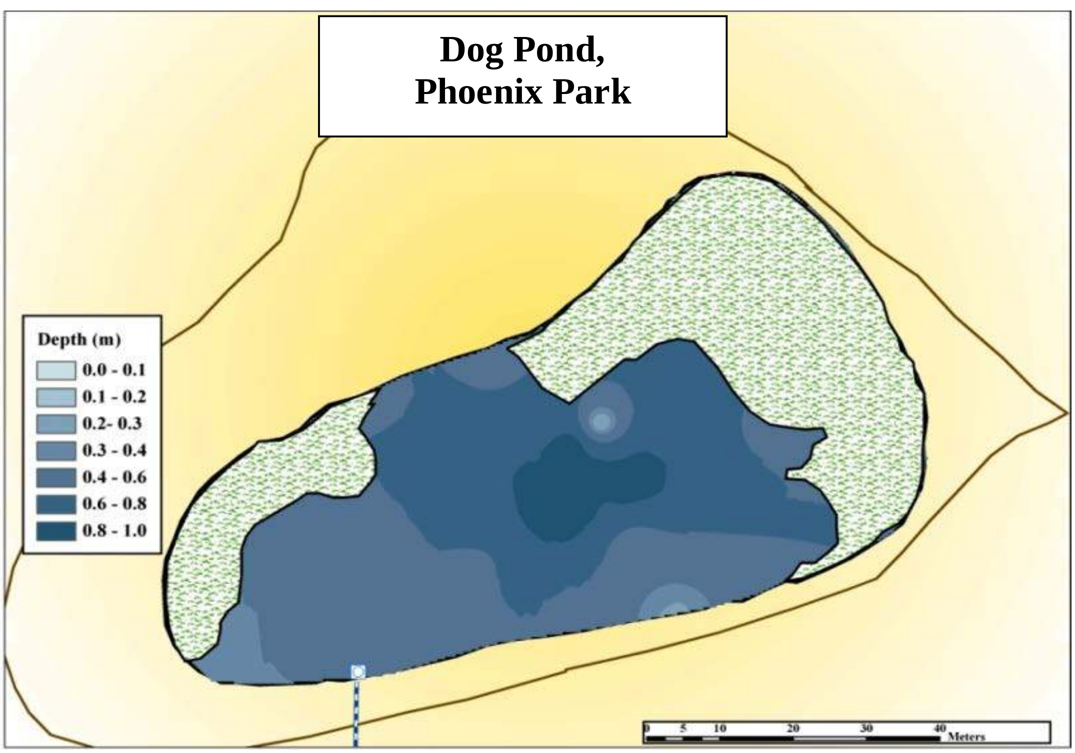

Figure 23. Bathymetric profile of Dog Pond, Phoenix Park, conducted in June 2007.

(b) Water Quality

Water temperatures reached a high of 23.2^{o}C in June, decreasing to 16.3^{o}C in the autumn. Water clarity was moderately good during both surveys and Secchi disc readings to the pond bed (at 1m) were recorded. The water exhibited a slight green hue, however, indicating the presence of relatively small amounts of phytoplanktonic algae. Chlorophyll values confirmed this finding, although a relatively high reading of 37µg/l was recorded at the outflow in June (Table 12). Moderately low levels for Conductivity and Alkalinity were recorded in June and October 2007 (Table 12).

Table 12. Physico-chemical data recorded from the Dog Pond, during 2007. Results in red indicate breaches in parameters (see Table 1).

Dog Pond Site	Date	Total P Mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Inflow	June 07	0.028	<0.006	<0.049	170	1.45	16.642	21	<1	21
Mid - lake	June 07	0.054	<0.006	<0.049	167	1.5	14.2	24	<1	23.2
Outflow	June 07	0.105	0.09	<0.049	168	1.67	36.98	20	<1	21.4
Inflow	Oct. 07	0.196	0.08	<0.049	170	1.83	14.2	42.5	<1	16.3
Outflow	Oct. 07	0.132	<0.006	<0.049	168	1.86	16.7	32.3	<1	16.4

Phosphorus levels exceeded the guideline limit at most sites, with elevated readings for TP (>0.1mg/l) and MRP (≥0.08mg/l) recorded on both sampling occasions (Table 12). It is difficult to ascertain the source of this phosphorus input to the water column, as it is unlikely to have originated externally through land runoff. The release of phosphorus from sediments and decaying leaf litter may have contributed to the high nutrient levels in the water column. Tests were also undertaken for total and faecal coliforms, but levels of both were negligible, suggesting no faecal or bacterial contamination to this pond. Overall, results for the Dog Pond indicate that, while values for most parameters were broadly within acceptable limits, the pond water was enriched with the nutrient phosphorus.

(c) Macrophytes

Tall marginal reeds (*Typha latifolia*) dominated the macrophyte flora of the Dog Pond (Plates 34 & 35a). The reed beds were virtually monospecific and encroached into the water for distances up to 15m. It is estimated that these reed beds occupied up to 35% of the original pond area. Lesser stands of Reed canary grass (*Phalaris arundinacea*) and Yellow flag (*Iris pseudacorus*) were present at the margins of the dense *Typha* beds. The southern bank of the pond is densely shaded with tall trees and is less conducive for aquatic plant growth (Figure 35b).

The submerged flora in the open watercourse was dominated by the pollution- and disturbance-tolerant Canadian pondweed (*Elodea canadensis*). This plant produced continuous vegetation stands that carpeted the pond bed over *circa* 60% of its area. The individual plants were deep green in colour and in a healthy condition. Moderate stands of another pollution and shade-tolerant species, Curly-leaved pondweed (*Potamogeton crispus*), were present in the open water. More isolated, low-growing stands of Fennel pondweed (*P. pectinatus*), Lesser pondweed (*P. pusillus*) and Stonewort (*Chara* sp. (cf. *vulgaris*)) were also recorded. Clumps of the submerged, free-floating Ivy-leaved duckweed (*Lemna trisulca*) carpeted the submerged, rooted flora.

Plate 34. Extensive stands of Reedmace (*Typha latifolia*) in the Dog Pond, Phoenix Park, in 2007.

Occasional rafts of Amphibious bistort (*Polygonum amphibium*) and Unbranched burreed (*Sparganium emersum*) were present at the edges of the open water.

Plate 35. Views of the Dog Pond, Phoenix Park, showing a) marginal communities on northern shore and b) the extent of shading on southern shore (left foreground).

(d) Macroinvertebrates

The Dog Pond provided an array of mesohabitats for macroinvertebrates, including exposed sediments, marginal emergent flora, submerged aquatic plants and shallow marginal areas with an abundance of leaf litter. A good range of taxa was recorded in this pond (Appendix III), with very high numbers of molluscs and water boatmen (Corixidae), making it the most productive pond in the Phoenix Park in terms of numbers of individuals. Samples collected in exposed sediments had the lowest numbers of taxa and individuals, with the highest diversity recorded from those fringes of the pond that were dominated by the emergent Reedmace. Molluscs were a very prominent feature of the macroinvertebrate community, with juveniles of the gastropod Hydrobiidae and the bivalves *Sphaerium* sp. and *Pisidium* spp. being very abundant in the marginal flora. The Ramshorn snail *Planorbis albus* (Plate 36), a snail common in ponds with abundant plant life, was very numerous in areas of the pond covered with *Elodea canadensis* and *Potamogeton crispus*. Water boatmen were visibly numerous within the submerged flora and were recorded in high numbers.

Plate 36. The Ramshorn snail (*Planorbis albus*) was particularly abundant in the submerged vegetation present in the Dog Pond, Phoenix Park.

The shaded, silted areas that were covered with leaf litter (Plate 35b) were dominated by the bivalves *Sphaerium* sp. and *Pisidium* sp., together with juvenile Hydrobiidae and *Asellus aquaticus*.

(e) Fish

An extensive netting and electrofishing survey was conducted on the Dog Pond in order to assess the fish population (Figure 19, Plate 37 a).

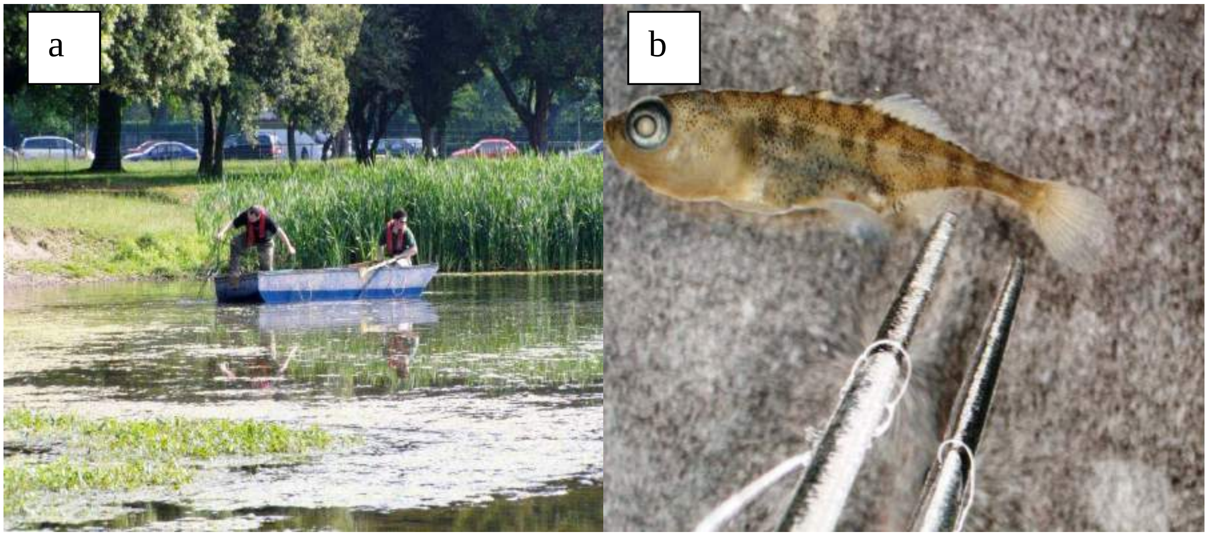

Plate 37. A fish stock survey of the Dog Pond, Phoenix Park (a) revealed only three-spined stickleback (b).

Only one species, the three-spined stickleback (*Gasterosteus aculeatus*) (Plate 37b), was recorded, although it was present in large numbers. The three-spined stickleback is a small fish that grows to a maximum of 10cm, although they rarely achieve a fork-length over 6cm (Wheeler, 1969). In Ireland, they are extremely common and widespread, and are found in virtually all waters, with the exception of fast-flowing streams. Males are recognisable during the breeding season by their bright red colouration under the head and belly. They are extremely territorial at this time, building nests for the incubation of eggs. Three-spined sticklebacks feed on a variety of prey species including tubificid worms, molluscs (*Sphaerium* and Hydrobiidae), crustaceans (such as *Gammarus* and *Asellus*) and midge pupae and larvae. Three-spined sticklebacks are, in turn, preyed upon by a number of aquatic animals and birds such as the otter, kingfisher and heron.

3.5.3. Discussion

Water quality assessment of the Dog Pond revealed high levels of the nutrient phosphorus in the water column. Water clarity was good during the June and October surveys, with no evidence of significant algal blooms. An abundant and varied macrophyte flora was recorded in the Dog Pond. The pond supported a thriving macroinvertebrate fauna, with high numbers of crustaceans, water boatmen, molluscs and leeches, all availing of the variety of mesohabitats present in the pond. These species belong to families that have a tolerance of organic pollution and would be characteristic of a productive pond such as this.

Previous studies revealed a chequered history with regard to fish populations in the Dog Pond. On finding no fish at all in the pond, a 1974 study conducted by the IFT recommended that it may be suitable for stocking with carp. If this stocking was successful, the carp could be used as brood stock for supplying other ponds in Phoenix Park. In 1976, 200 young carp (0+) were released into the pond. A survey conducted in 1979 recorded only a single specimen. A subsequent study conducted in 1987 (ERFB, 1987) reported that the pond contained rudd, roach, perch and rudd/roach hybrids and that these fish were probably a result of stocking operations carried out unofficially, by anglers, between 1979 and 1987. This report also mentioned that carp were known to be present in the water body, but none were captured or observed during survey work.

Results from the current study reveal that no angling species were reported in the Dog Pond, despite the variety of fishing techniques employed during the survey. Three-spined sticklebacks were recorded in the macroinvertebrate samples, with the majority of these occurring within the Reedmace beds. A number of factors may explain the absence of coarse fish in the Dog Pond. The physical characteristics of the pond, with its shallow depth, large fluctuations in water temperatures and excessive aquatic plant growth in summer may render the habitat unsuitable for most coarse fish species. It is also possible that over exploitation by anglers may have removed species, such as carp, that were present in the pond in earlier years.

3.5.4 – Recommendations for future management

The Dog Pond provides an attractive water feature in the open parkland and it is easily accessible from the main road that traverses the Phoenix Park (Chesterfield Avenue). The pond is visually attractive, with its dense stands of emergent macrophytes occupying the margins and the variety of submerged aquatic plants present in the main watercourse.

Consideration should be given to removing a large proportion of the emergent Reedmace beds in the pond. The encroaching and rapidly expanding reed beds currently occupy *circa* 35% of the pond area and will overgrow the entire pond if left unchecked. The reeds may be removed mechanically, by dredging, or chemically using an approved herbicide. Not all of the stands should be removed, as these enhance the visual appeal of the pond, while also creating valuable habitat for aquatic biota, waterfowl and wildlife. By removing a proportion of these reed beds, a larger body of open water will be available for fish and for angling.

The Dog Pond could have a broader recreational function than simply providing a visual attraction within the park. With its ease of access, the pond could be developed as a small angling amenity. The species that would best suit this productive, shallow and vegetated watercourse would be carp and tench. The physical conditions within the pond could be improved for fish and angling by dredging some of the deep mud deposits and creating an area with a water depth of 2 to 3m. This would provide a refuge for fish during the warmer and colder months. It would also provide an area where submerged weed growth would be less vigorous. This work could be conducted while removing some of the mass of reedbed. Further fishery enhancement measures would involve the installation of a small number of angling stands. This could help establish the pond as a reputable carp and tench fishery within the Phoenix Park.

3.6. ISLAND POND (No. 6 - System C)

3.6.1. Introduction

The Island Pond, also known as the Quarry Pond, is the largest pond in the Phoenix Park outside the Dublin Zoo complex. It is located to the south-west of Chesterfield Avenue, close to the Castleknock Gate (see Figure 1). This pond covers an area of *circa* 1 hectare, although an island measuring *circa* 0.5ha occupies a large fraction of the open water (Figure 21). The island is totally overgrown with laurels, willows and tall deciduous tree species. The pond is encircled by tall and expansive deciduous trees and is bordered by an earthen path. It is popular among walkers, joggers and those who come to the pond to feed the population of mallard ducks that reside in the pond (Plate 38).

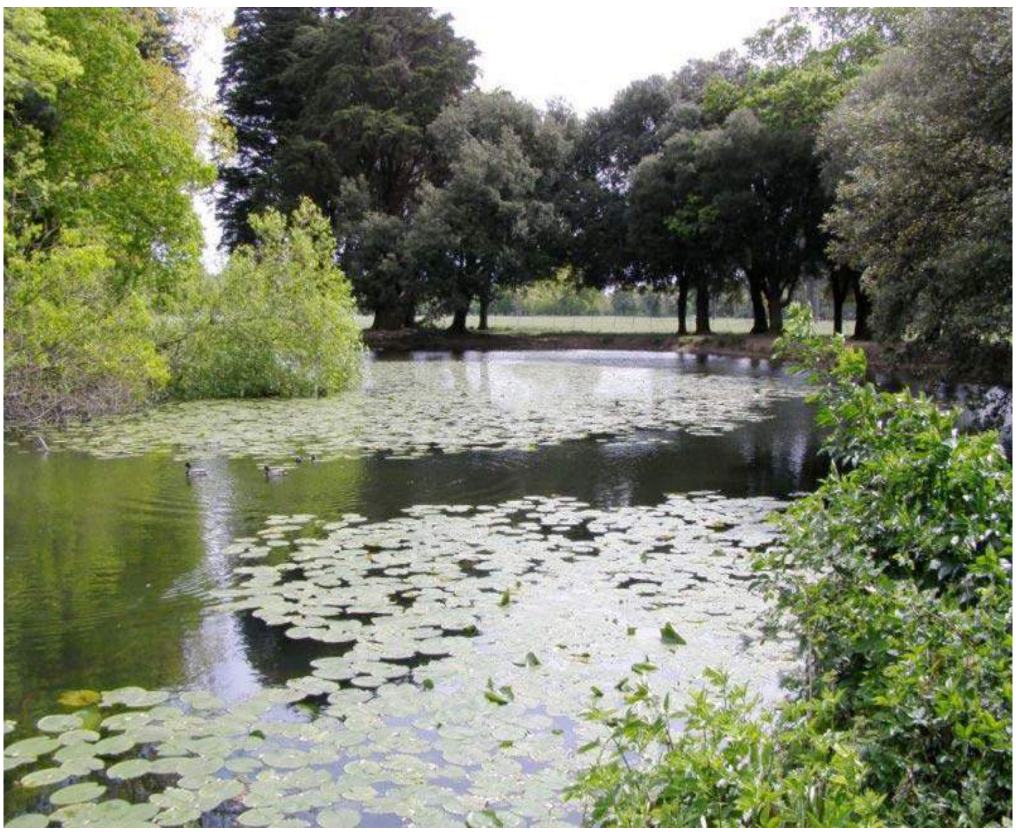

Plate 38. A view of the Island Pond, Phoenix Park, from the western end in June 2007. Large beds of Yellow water lily and a number of mallard are visible on the pond.

This is an "off-line" pond (see Section 1.3). No inflowing water was detected during the course of the survey, even in June following prolonged periods of rainfall. Nor did a literature search shed light on the original water source. The Magazine Stream is located to the west of the pond (see Figure 1) and it is probable that this watercourse is the principal supply to the pond, particularly during times of high flow. Excess water in the pond is discharged through a brick-clad outflow and a dug trench on the south-western shore (Figure 24, Plate 39 b).

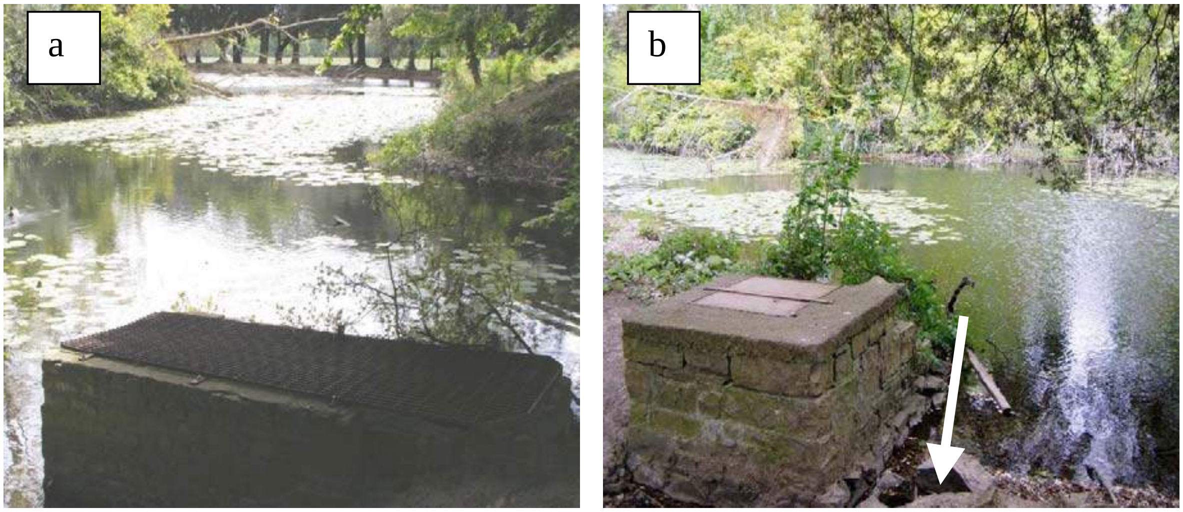

Plate 39. The Island Pond in the Phoenix Park showing a) the outflow and b) the inflow to the pond.

Plate 40. Fallen trees and beds of Yellow water-lily (*Nuphar lutea*) in the Island Pond, Phoenix Park.

Many of the trees on the island that occupies the centre of the pond are old or have died and fallen into the water body (Plate 40). This has permitted the colonisation of the island by more aggressive species, such as Rhododendron. The woody vegetation on the island and surrounding the entire water body casts a heavy shade on the pond. The pond floor is densely carpeted with leaves and detritus in various stages of decomposition.

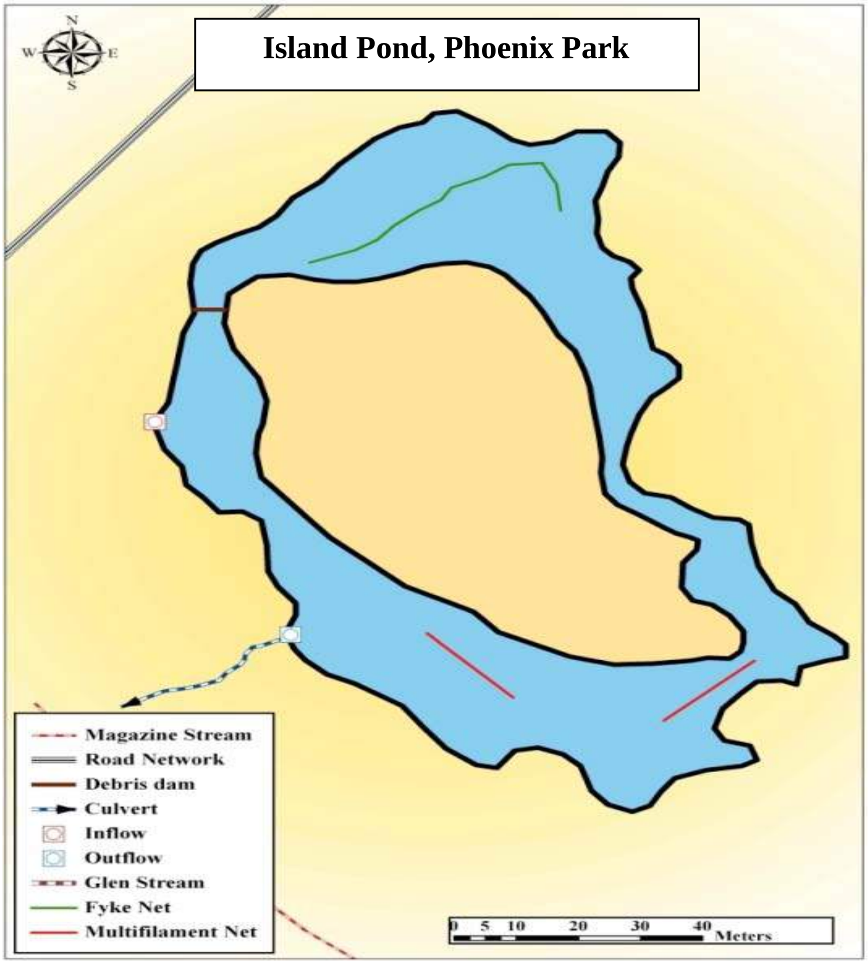

Figure 24. Map of the Island Pond, Phoenix Park, showing the location of gill and fyke nets used to sample the fish population present in the pond during survey work in summer 2007.

The Island Pond currently provides an amenity for the public in the Phoenix Park, as part of the walks and trails that cover this particular area. In the Dáil Éireann debate on the "Development of the Phoenix Park" on 7th May 1975 (http://historical–debates.oireachtas.ie), a question was posed regarding "further planting and cleaning up" of the Island Pond. It is not known if these considerations were taken into account and if planting did take place in this period. Fish stock surveys were undertaken by the IFT (Inland Fisheries Trust) in 1974 and by the ERFB in 1987. These findings will be discussed in Section 3.6.3.

3.6.2. Results

(a) Bathymetry

Water depths in the Island Pond ranged between 0.2 and 3m in June 2007. A small, deep depression (3m) was located to the north of the pond (Figure 25). The mean depth recorded at the time of the survey was 1.0m.

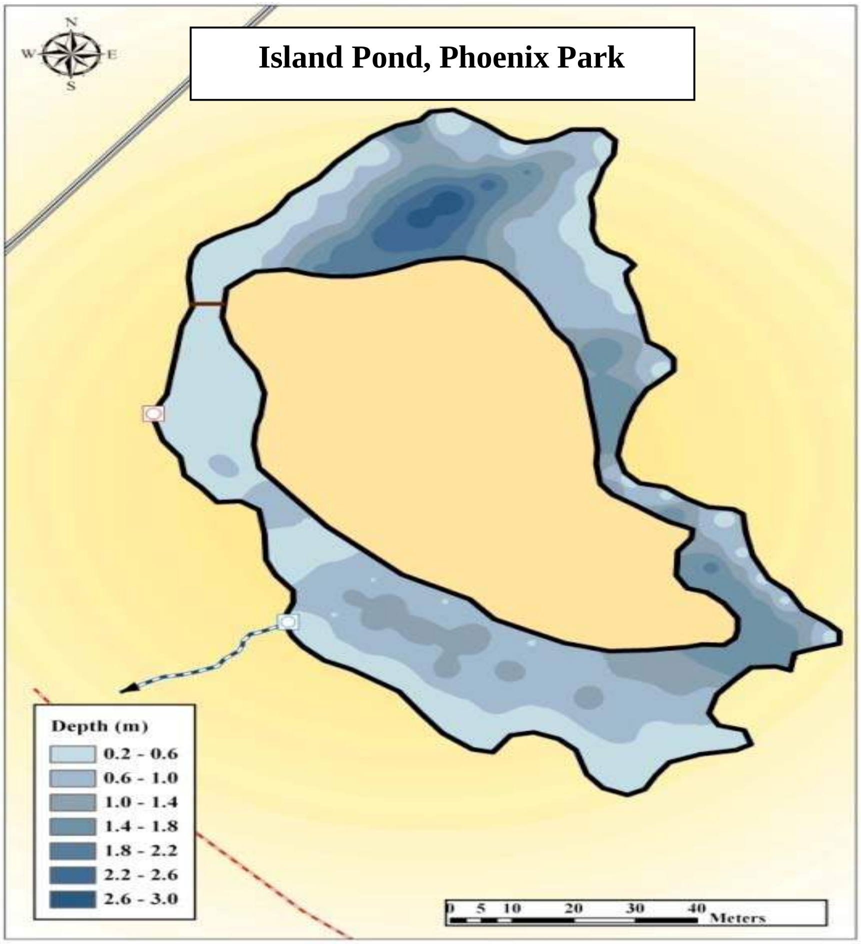

Figure 25. Bathymetric profile of the Island Pond, Phoenix Park, in 2007.

(b) Water Quality

Secchi disc readings to a depth of 2.2m were recorded, indicating good water clarity. This was reflected in the low chlorophyll levels that were obtained in June and October 2007 (Table 13). Temperatures ranged from 20.1^{o}C in June to 15.6^{o}C in October. The highest Conductivity reading was recorded in June at 380µS/cm (Table 13, Appendix I). The Alkalinity (meq/l) levels were high in comparison to other ponds in the park

(Appendix I). This is probably due to the water chemistry of the Magazine Stream, which is thought to supply the Island Pond. This stream is a rich calcareous water source and water samples recorded further downstream, in an open section of the stream, also revealed a similar water chemistry (see Section 3.9.).

Table 13. Physico-chemical data recorded from the Island Pond, during 2007. Results in red indicate breaches in parameters (see Table 1).

Island Pond Site	Date	Total P mg/L	MRP mg/L	TON mg/L	Cond. µS/sec	Alk. meq/L	Cphyll a µg/L	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Inflow	June 07	0.098	<0.006	<0.049	380	5.861	2.67	190	20	20.1
Mid - Lake	June 07	0.067	<0.006	<0.049	380	5.314	6.55	120	20	20.1
Outflow	June 07	0.109	0.026	<0.049	368	5.908	9.82	230	60	20.1
Inflow	Oct. 07	0.12	0.048	<0.049	367	5.955	3.5	150	<1	16.1
Outflow	Oct. 07	0.111	0.07	<0.049	379	6.11	5.42	160	<1	15.6

Results of nutrient analyses showed that phosphorus levels were well in excess of the guidelines (see Table 1), with values of TP exceeding 0.1mg/l (threshold 0.063mg/l) and with MRP levels reaching a peak of 0.07mg/l (threshold 0.02mg/l). It is difficult to state conclusively where the high phosphorus inputs originate.

Plate 41. Tall overhanging vegetation casts a dense shade on the Island Pond in the Phoenix Park during a survey conducted in summer 2007.

Internal loading from sediment release and decaying leaf litter probably contribute to the levels of phosphorus recorded, in addition to faecal matter from the mallard population on the pond. The lack of light penetration (Plate 41), together with the large volume of decaying leaf material in the Island Pond, is certain to have created anoxic conditions in the sediments. Anoxic sediments are prone to phosphorus release, thus adding to the levels of nutrients already present in the water column. The high phosphorus levels recorded at the inflow in June and October, however, suggest that the source of water to the pond is also enriched. Bacteriological analysis of water samples indicated that total and faecal coliform counts were extremely low in this pond.

Overall, physico-chemical sampling has shown that the Island Pond had a eutrophic status, with levels of phosphorus exceeding the guideline limits in most samples (Table 13).

(c) Macrophytes

The island and the banks of the Island Pond are densely vegetated with tall trees and leafy shrubs. These cast a deep shade on the pond margins and on the water itself (Plates 38, 40, 41, 42, 43). This probably accounts, in large part, for the restricted marginal reed and fringing herb flora in this pond (Appendix II, Plate 42). Where light penetrates to the pond margins, relatively small, low-growing plant assemblages were present. These included Water mint (*Mentha aquatica*), Water plantain (*Alisma plantago-aquatica*), Brooklime (*Veronica beccabunga*), Branched burreed (*Sparganium erectum*), Rush (*Juncus* sp.) and Sedge (*Carex* sp.).

Plate 42. The impact of dense overhead shading is evident in the exposed margins that occupy much of the Island Pond in the Phoenix Park.

Beyond this sparse emergent vegetation zone, extensive stands of Yellow water-lily (*Nuphar lutea*) (Plate 43) were commonly present. This was the dominant macrophyte species in the Island Pond and occupied *circa* 30% cover of the open water during the summer of 2007. Two free-floating species, Common duckweed (*Lemna minor*) and Ivy-leaved duckweed (*L. trisulca*), were also recorded, although with considerably less abundance. The *L. trisulca* remained submerged and formed thin vegetation mats on the decaying leaf litter.

Plate 43. Beds of Yellow water lily (*Nuphar lutea*) in the northern section of the Island Pond, Phoenix Park, in 2007

The submerged plant component of the flora was dominated by the filamentous green alga *Spirogyra intestinalis.* Loose carpets of this 'slimy' alga were present throughout the pond and occupied up to 50% bottom cover during the summer months. Lesser carpets of the more robust filamentous alga Blanketweed (*Cladophora* sp. (*cf. glomerata*)) were present, notably in more open pond sections. Rooted submerged plant species were neither abundant nor diverse in this deeply shaded and nutrient-rich pond.

The only species recorded, with low abundance, were the Stonewort (*Chara vulgaris*) and Lesser pondweed (*Potamogeton pusillus*).

(d) Macroinvertebrates

The Island Pond supported a poor macroinvertebrate community (Appendix III) that was dominated by the crustacean species *Asellus aquaticus* and the freshwater shrimp *Crangonyx pseudogracilis*. All other taxa were poorly represented, particularly molluscs, with only a small number of individuals recorded in this pond. The number of mesohabitats available for sampling was limited. Sweep net samples were taken through the floating-leaved Yellow water-lily and in marginal areas of the pond covered with decaying leaf litter and patches of filamentous algae. The Water louse (*A. aquaticus*) was abundant in the leaf litter sample. This species is a detritivore whose diet consists of decaying plants, algae and carrion. Sampling through the water-lily revealed large numbers of water boatmen (Corixidae) and relatively large numbers of the mayfly (*Cloeon dipterum*). The latter species was the most frequently occurring mayfly species in the Phoenix Park ponds. It typically occurs in running and standing freshwaters and may indicate eutrophic conditions in ponds.

Results of this survey showed the Island Pond to have a depauperate macroinvertebrate fauna. The prevalence of large amounts of leaf litter and the absence of an abundant marginal flora is undoubtedly important in explaining the low numbers of benthic invertebrates in this pond.

(e) Fish

Two fish species were recorded during the 2007 survey. Two multimesh nets and one fyke net were used to sample areas of open water in the pond (Figure 24). Electro-fishing was used to sample for fish in areas where netting was not possible, such as under overhanging trees around the islands perimeter and within the extensive water-lily beds (Figure 24, see Plate 40). All of the fish recorded were captured in multimesh nets.

Perch was the most numerous species, comprising 56% of the total number of fish captured (Table 14, Figure 26). The fish ranged from 8.5–29cm in fork length and 35-429g in weight (Table 14). A CPUE for perch of 5.5 was recorded, indicating a relatively small population of fish.

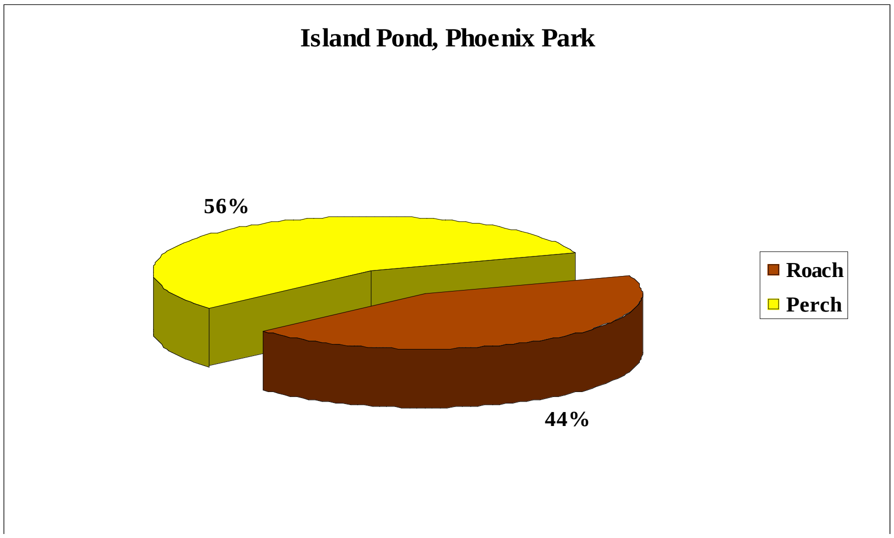

Figure 26. Relative representation of each fish species captured in the Island Pond in June 2007.

Table 14. Catch Per Unit Effort (CPUE), mean length and weights of species captured in Island Pond in June 2007.

Island Pond	No.	CPUE	Length (cm)	Weight (g)
Roach	11	5.5	15 14-17	55 39-79
Perch	14	7	17.8 8.5 - 29	138.93 35 - 429

The length frequency histogram for the small number of perch captured during the survey revealed an even distribution of fish over a number of age classes (Figure 24). No perch fry were observed during the survey, although it is possible that they were present beneath the water lily leaves.

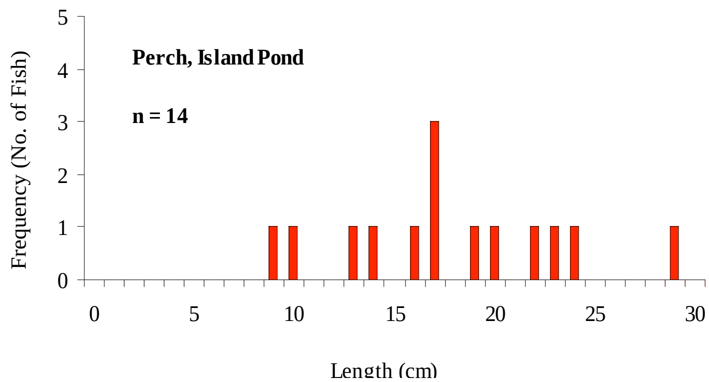

Figure 27. Length frequency distribution of perch captured in the Island Pond, Phoenix Park in June 2007.

Plate 44. Processing of fish captured from the Island Pond, Phoenix Park, in June 2007.

Roach (*Rutilis rutilis*) comprised 44% of the fish population in the pond (Figure 28). The fish were small and ranged from 14-17cm in fork length and 39-79g in weight (Table 14).

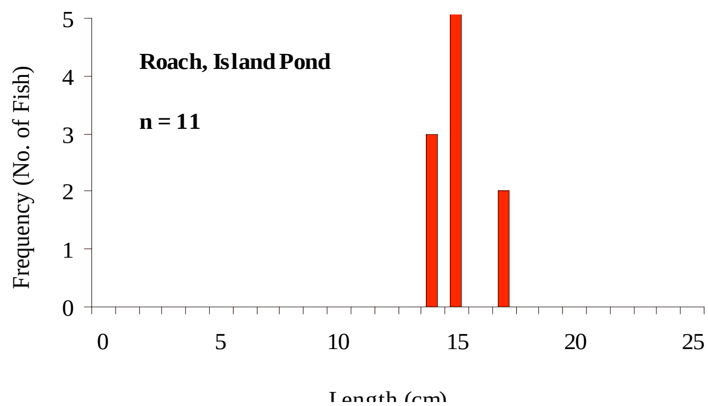

Figure 28. Length frequency distribution of roach captured in the Island Pond, Phoenix Park, in June 2007.

Length frequency data revealed that only two year classes of roach were present (Figure 28). These fish were aged 6+ (14-15cm) and 7+ (17cm). No fry or juvenile roach were observed during netting or electro-fishing operations.

3.6.3. Discussion

The Island Pond displays all the classic characteristics of a well established, mature, off-line pond. This is reflected in the dominance of the Yellow water-lily (*Nupar lutea*), which covers large sections of the pond's surface. Dense shading from tall, overhanging trees on the island and along the margins of the pond has created unfavourable conditions for the establishment and growth of an aquatic flora. As far back as 1987, the pond was described as being in a neglected state (ERFB, 1987) and it is likely that conditions have deteriorated further since this observation was made.

Current investigations have shown that the water in the pond is excessively enriched with phosphorus. This is most likely the result of internal loading from anoxic sediments, which in turn are a product of diminished light penetration and decomposing leaf litter (Trevor Champ, CFB, pers. comm.). Shading from the tree canopy has also negatively impacted on aquatic macrophyte growth, with emergent plants confined to a small corner of the pond and the poorly-diverse submerged flora dominated by filamentous green algae. The lack of mesohabitats in the Island Pond was reflected in its poor benthic macroinvertebrate composition, which was dominated by the crustacean *Asellus aquaticus*. *Asellus* was particularly abundant in the leaf litter samples, while water boatmen (Corixidae) were common amongst the water-lilies. The virtual absence of gastropod and bivalve snails probably reflects the paucity of aquatic macrophytes.

The pond has undergone several fish stock assessments in the past and this historical data gives an indication of how the pond has deteriorated in terms of its biological productivity over the decades. In 1974, an IFT survey described the pond as a 'rich, shallow and attractive water'. In that survey large stocks of perch, rudd and small bream (*Abramis brama*) were present. Indeed, recommendations were made to introduce piscivorous pike (*Esox lucius*) as a means of controlling the populations of perch and rudd. It was also recommended that tench be introduced to increase the diversity of its fish stocks (IFT, 1979).

In 1987, a further survey was undertaken by the ERFB and the findings revealed a stock of perch, rudd and pike in the Island Pond. All three species were recorded in low numbers and the pond was described as being in a 'state of disrepair' (ERFB, 1987). Age data revealed a very slow growing population and one rudd specimen measuring 21.5cm was 14 years old (ERFB, 1987). In productive waters, such as Coosan Lough on Lough Ree in Co. Westmeath, a rudd of this size would be approximately 7 years old (Kennedy & Fitzmaurice, 1974, Appendix IV). Bream (*Abramis brama*) were also believed to be present, although none were recorded during the 1987 survey. Angling reports indicate that bream were present in the Island Pond during this period (P. Bourke, CFB Angling Adviser, pers. comm.). Fish stock analysis in the current study revealed a different dynamic in the fish community, with only small numbers of perch and roach recorded. Roach were not reported from either of the two previous studies, indicating that they had been introduced from an unknown source within the past 20 years. The absence of rudd in 2007 is a notable find and it is possible that this sensitive species has been competitively excluded from the pond by the more aggressive and adaptable roach. Since the rapid spread of roach began in Ireland, approximately 25 years ago, there has been a drastic reduction in the numbers of rudd in watercourses throughout the country (Caffrey & McLoone, 2004; Caffrey & Conneely, in press).

Overall, fish numbers were low in this pond, with only 14 perch and 11 roach recorded from fishing operations. With its lack of spawning habitat, cover and food availability, it appears that the Island Pond does not, currently, have the capacity to support a large fish population. While a number of age cohorts were recorded for perch, no juvenile roach were observed during this survey. The lack of aquatic macrophytes to provide spawning habitats may be an important factor here, as the preferred spawning medium for perch is wood debris, of which there was an abundant supply in the Island Pond (Plate 38). Age analysis revealed the roach population to be slow growing when compared to other ponds within Phoenix Park and with waters throughout the country. A specimen of 14cm from the Island Pond was 6+ years old. A similar sized specimen from the Machine Pond (Section 4) was just 4+ years old (Appendix IV). In comparing data from the current study against UK standard growth curves (Cowx, 2001), the roach population in the Island Pond was ranked as having an average to slow growth rate.

3.6.4. Recommendations for future management

The first consideration in any future management plan for the Island Pond would be to increase light availability to the water column. This would stimulate the bacterial decomposition of leaf litter, while also encouraging the growth of marginal and aquatic vegetation. Light penetration could be improved by controlling the *Rhododendron* cover on the island and by reducing the density of the ageing tree canopy surrounding the pond itself. It may be necessary to propagate the bankside vegetation in order to stabilise the currently exposed margins of the pond. One way of achieving this may be to arrange staked willow bunches (or faggotts) between 1 and 1.5m out from the water's edge and to replant the area behind these with marginal plants. Bankside recolonisation might also be expedited by transplanting live rhizomes from a range of reed species into the pond margins. Reedmace rhizomes from the Dog Pond could be used to start this operation. Considerable success has been achieved using this technique in rehabilitating newly constructed canal banks (Caffrey & Beglin, 1996).

In the long-term, it is recommended that fish stocking operations are carried out in the Island Pond to enhance the meagre existing fish population. Species such as rudd and tench would be ideal for this purpose and these are readily available from ponds within Phoenix Park. The introduction of small numbers of bottom feeding species, such as bream, could also improve conditions in the pond. Their foraging activities may encourage the decomposition of the leaf material by introducing oxygen from the water column into the anaerobic sediments. Finally, the reintroduction of a population of rudd into this pond would be of valuable scientific interest by providing a template to examine the competitive interaction between this species and the more aggressive roach.

3.7. MACHINE POND (No. 7 - System D)

3.7.1. Introduction

The Machine Pond, or Castleknock Pond as it is known locally (Plate 45), is located at the northern end of the park near the Castleknock Gate and directly adjacent to Chesterfield Avenue (see Figure 1).

Plate 45. The Machine Pond, Phoenix Park, in June 2007.

The culverted Viceregal Stream runs alongside the Machine Pond *en route* to the Áras Pond and the Dublin Zoo complex, before draining into the River Liffey. The pond has an inflow and outflow on its north-western and south-western shores, respectively (Plate 46 & Figure 29). While there is no information available on the water supply to the pond, the alignment of the inflow and outflow corresponds to the Viceregal Stream, suggesting it is an off-line pond supplied by this stream. During the survey period, the flow of water from the inflow was negligible. The stream probably acts as an intermittent source of water, depending on rainfall.

Plate 46. Outflow from the Machine Pond, Phoenix Park.

The Machine Pond is situated among a series of paths and trails that follow along Chesterfield Avenue. It is one of the smaller ponds in the Phoenix Park, covering an area of 0.18 hectares. A metal fence encircles its perimeter (Figure 29). Although enclosed, the pond functions as a visual amenity, as well as providing a wildlife refuge in the northern section of the park. According to park staff, it was used as a depositary for old machinery and other heavy equipment in former times, hence the pond's name.

Over the past 30 years, several fish stock surveys have been undertaken in the Machine Pond. In 1974, the IFT carried out a netting survey while, in 1987, a fish stock assessment was undertaken by the ERFB. The findings of these reports are discussed in Section 3.7.2. (d).

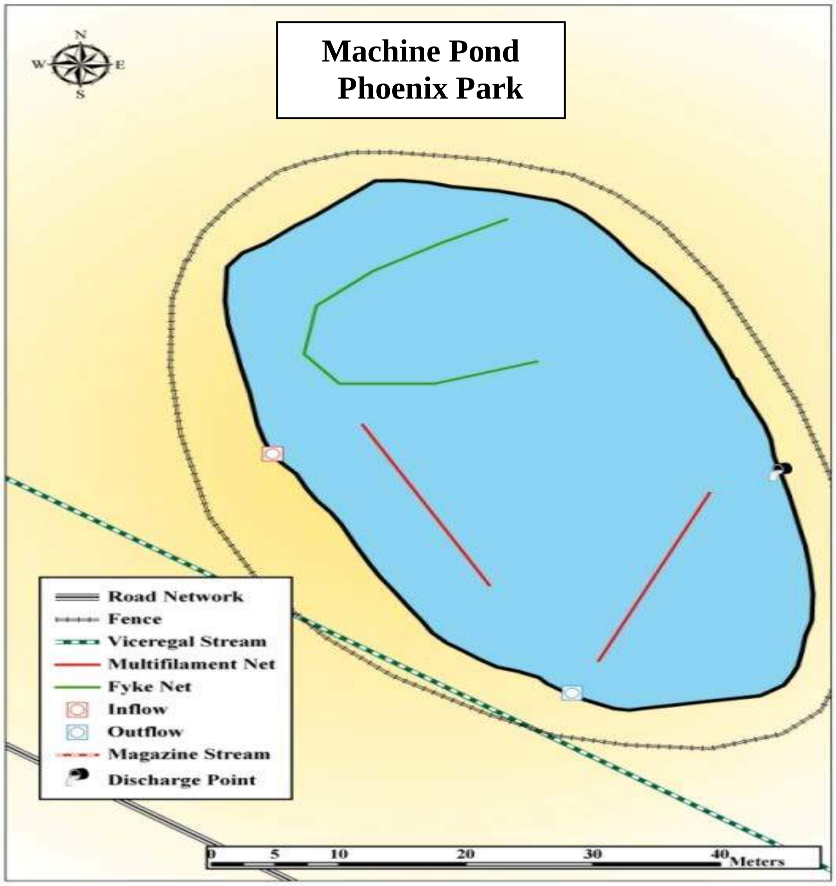

Figure 29. Map of the Machine Pond, Phoenix Park, showing the position of nets used to sample the fish stock in 2007

The Machine Pond has all the appearance of a pond that has received little or no management attention in years. Tall willows have encroached into the water and the pond margins are strewn with fallen trees and branches (Plate 47).

Plate 47. Fallen trees and encroaching willows provide the focal point for the Island Pond, Phoenix Park

3.7.2. Results

(a) Bathymetry

Water levels in the Machine Pond varied considerably during the survey period. In June 2007, following a prolonged period of heavy rainfall, high water prevailed and a maximum water depth of 4m was recorded (Figure 27 & Plate 48). By October 2007 the water level had dropped approximately 0.6m, exposing large areas of bare bank (Plate 49).

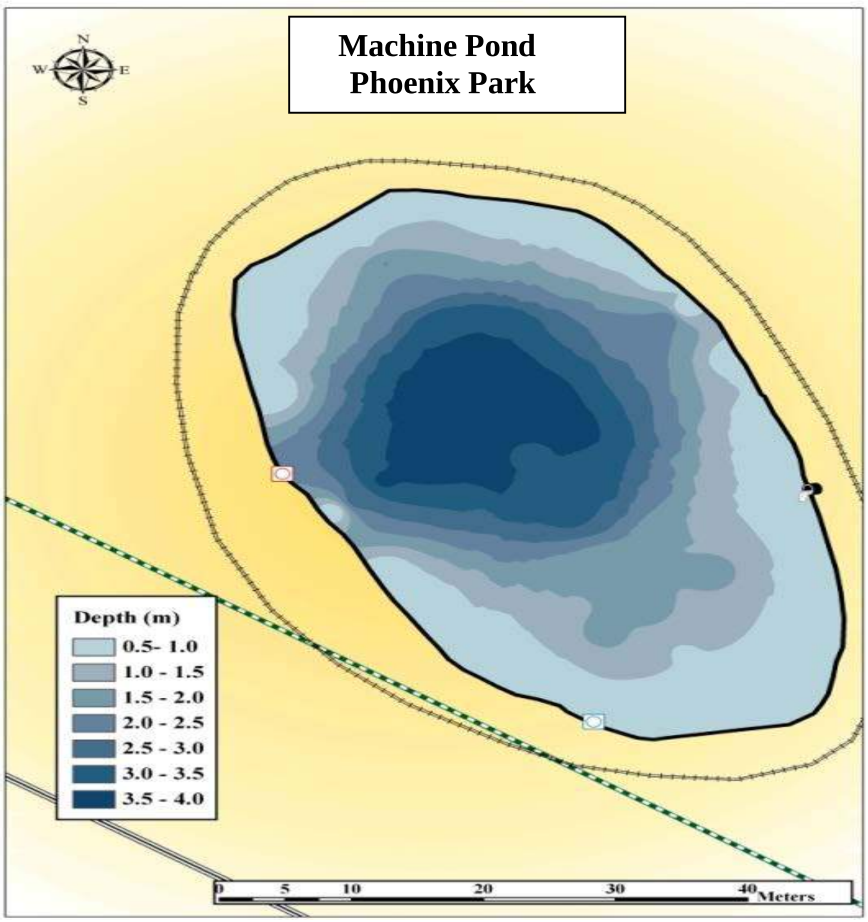

Figure 30. Bathymetric profile of Machine Pond, Phoenix Park, recorded following heavy rainfall in June 2007.

Plate 48. High water levels prevailed in the Machine Pond, in June 2007, following heavy rainfall.

This level of water fluctuation was not observed in any of the other ponds in the Phoenix Park in 2007. It suggests a significant influx of water during periods of high rainfall, although the exact source has not been determined.

Plate 49. Areas of bare bank exposed by dropping water levels in October 2007 in the Machine Pond, Phoenix Park.

(b) Water Quality

Water temperatures in the Machine Pond recorded during the June survey reached 20.1°C. The ambient temperatures dropped to a low of 15.9°C in October. Conductivity values ranged from 381µS/cm to 412µS/cm in this pond, indicating a relatively hard/alkaline water (Table 15 & Appendix I). Low levels of chlorophyll and good water clarity indicated the absence of any phytoplankton bloom during the survey period. However, nutrient analysis revealed that TP values exceeded the guideline limits (>0.063mg/l) in all but one sample (Table 15). MRP levels were very low in this pond, which may reflect uptake by submerged macrophytes. Bacteriological analysis of the water showed compliance with the standards, with low numbers of total and faecal coliforms recorded.

Table 15. Physico-chemical data recorded from the Machine Pond, during 2007. Results in red indicate breaches in parameters (see Table 1).

Maxhine Pond Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	°C
Inflow	June 07	0.093	<0.006	0.498	409	2.99	9.533	310	<1	20
Mid - lake	June 07	0.024	<0.006	0.238	398	3.73	1.269	380	<1	19.8
Outflow	June 07	0.09	<0.006	0.128	412	3.856	1.429	100.6	30.2	20.1
Inflow	Oct. 07	0.078	<0.006	<0.049	389	3.871	1.298	190.4	40.1	16.2
Outflow	Oct. 07	0.08	<0.006	<0.049	381	3.473	1.436	180.6	>1	15.9

During the June survey, a small flow of milky white liquid was observed discharging into the water *via* a small pipe on the northern bank. Analysis of this fluid indicated a highly caustic substance with a pH of 11.4. While the origin of this substance is not known, it exhibits properties akin to chemicals for domestic usage, such as drain cleaners. The discharge was not observed again over the duration of the survey.

(c) Macrophytes

Tall, deciduous trees, mainly willow (*Salix* spp.) grew around the perimeter of the Machine Pond, casting a dappling, rather than a dense shade on the water. In places, relatively low-growing and 'bushy' willows encroached up to 5m into the water (Plates

47 to 50). The marginal aquatic flora was relatively restricted by the more aggressive willows and occupies only localised bankside areas. The principal emergent species was

Plate 50. Marginal and emergent plant communities in the Machine Pond, Phoenix Park, in June 2007.

Reed canary grass (*Phalaris arundinacea*), which occupied less than 10% of the pond margins. The fringing herb Water mint (*Mentha aquatica*) occupied occasional dense vegetation stands, some of which were completely submerged and others of which produced floating carpets that were anchored to the margins. Both growth forms are commonly encountered in Irish aquatic habitats.

The floating-leaved plant community was represented by Yellow water-lily (*Nuphar lutea*), Floating-leaved pondweed (*Potamogeton natans*) and Unbranched burreed (*Sparganium emersum*). The former was well represented throughout the survey period (Plate 46), having already expanded its large floating leaves by June 2007. The bright yellow flowers provided a distinct visual appeal to the pond during the summer period. The plant occupied *circa* 30% surface cover between June and October. *Sparganium emersum* was most prevalent at the northern end of the pond, where it occupied *circa* 10% surface cover. Only a few small and isolated stands of *P. natans* were present.

The free floating and submerged plant Ivy-leaved duckweed (*Lemna trisulca*) formed dense tufts of light green vegetation on the submerged weed throughout the pond. This is a species that is tolerant of high levels of nutrient enrichment but that can also grow abundantly in clear water. Very little filamentous algae was recorded.

The submerged plant community was dominated by dense and often continuous stands of Canadian pondweed (*Elodea canadensis*). The plants were deep green in colour and displayed a very vigorous growth. In places, the vegetation occupied the full water column in water almost 2m deep. The *Elodea* occupied a bottom cover within the pond of *circa* 35% (Appendix II). This species is tolerant of enrichment and disturbance, and it is probable that its vigour in this pond reflects its better capacity to withstand the adverse effects of water level fluctuations that are experienced within this pond. Another submerged plant recorded in the Machine Pond was Lesser pondweed (*P. pusillus*). This relatively diminutive, long-leaf plant produced isolated dense stands that grew to the water surface in 2m of water.

(d) Macroinvertebrates

The Machine Pond was characterised by a poor macroinvertebrate fauna, with low numbers of individuals recorded across all taxa (Appendix III). The crustaceans *Asellus aquaticus* and *Crangonyx pseudogracilis* were the most abundant species, although their numbers were low in comparison to other ponds in the Phoenix Park. *Crangonyx* (see Plate 22) was the only freshwater shrimp to be recorded in the ponds during this survey. It is native to North America and its first Irish record was from a pond in Phoenix Park (Holmes, 1975). Evidence suggests it now has a widespread distribution in the inland waterways of Ireland (Gallagher & Caffrey, in prep.).

The Machine Pond had one of the least diverse macroinvertebrate communities of all the water bodies surveyed in the Phoenix Park. The pond was lacking in suitable mesohabitats along the margins, with only exposed sediments available for colonisation. The paucity of marginal aquatic vegetation was particularly important as the current study has reported high numbers of benthic invertebrates in ponds with a diverse marginal flora. Fluctuating water levels, which are a feature of this pond, would also create an unstable environment for aquatic macrophytes and macroinvertebrates alike.

(d) Fish

Two species of fish were recorded from the Machine Pond in 2007. Sampling was undertaken using two multimesh gill nets and one fyke net (Figure 29). Electro-fishing was also conducted. All of the fish recorded were captured using multimesh gill nets.

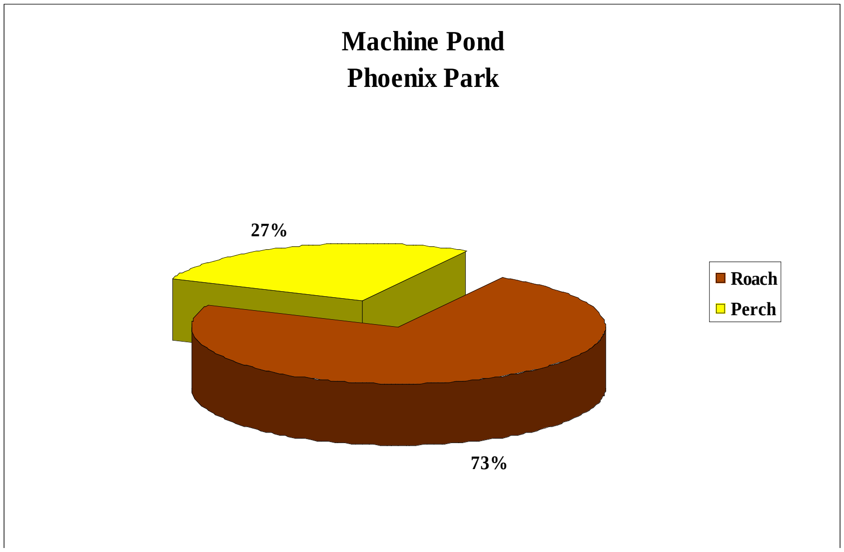

Figure 31. Relative representation of each fish species captured in the Machine Pond in June 2007.

Roach were the most numerous species captured, comprising 73% of the total number of fish captured in the Machine Pond (Figure 31). The fish ranged from 14-18cm in fork length and 31-95g in weight. A CPUE of 13.5 was recorded (Table 16).

Table 16. Catch Per Unit Effort (CPUE), mean length and weights of species captured during survey of Machine Pond in June 2007.

Machine Pond	No.	CPUE	Length (cm)	Weight (g)
Roach	27	13.5	15.4 14-18	56 31-95
Perch	10	5	17.3 8-24	11-240

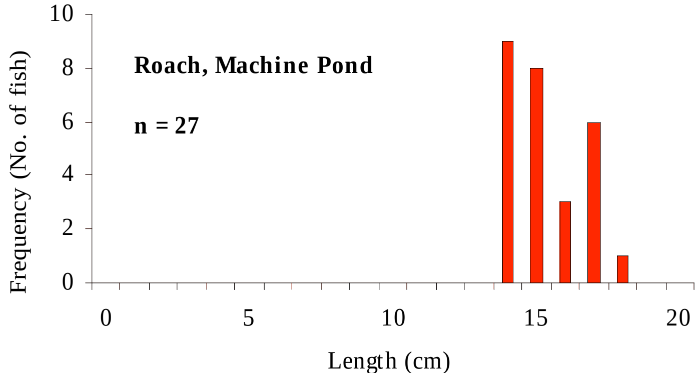

Figure 32. Length frequency distribution of roach captured in the Machine Pond, Phoenix Park in June 2007.

The length frequency distribution revealed two strong year classes among the roach captured. These were fish aged 4+ (14-15cm) and 5+(>15cm) (Figure 32). The absence of younger or older cohorts suggests an unbalanced population, although it is noteworthy that shoals of roach fry and juvenile fish (some probably 1+) were observed in the *Elodea* vegetation. Comparisons with UK standardised growth rates (Cowx, 2001) indicate the roach population in the Machine Pond has an above average growth rate.

Perch were also recorded, comprising 27% of the fish captured in the Machine Pond (Figure 31). The fish ranged from 8–24cm in fork length and 11-240g in weight (Table 16).

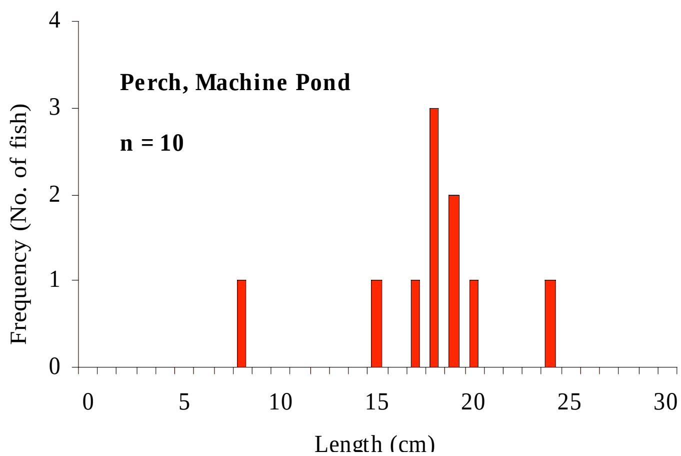

Figure 33. Length frequency distribution of perch captured in the Machine Pond, Phoenix Park in June 2007.

Length frequency data revealed a more balanced population than was recorded for the roach, with a number of distinct cohorts present (Figure 33). This suggests a small, self-sustaining perch population. Fry and juvenile perch were also observed in the dense submerged vegetation.

3.7.3. Discussion

While initial observations of the Machine Pond suggested that it represented a relatively healthy ecosystem, a more in-depth examination identified a number of physical and chemical stressors, including fluctuating water levels and the discharge of a potentially hazardous effluent.

Physico-chemical analysis revealed elevated levels of phosphorus in the water. As with most of the ponds in Phoenix Park, the high phosphorus content is thought to be a result, for the most part, of internal loading through sediment release. During the June survey, when rainfall was high, a caustic substance (pH 11.4) was observed discharging into the pond (Figure 32). While the origin of this substance and frequency of discharge is not known, further investigative efforts will be required to determine if it has had any impact on the pond's ecosystem.

The October survey was conducted during a period of dry weather and depth sounding results indicated a notable decline in water levels, when compared to results from the earlier survey. While strongly fluctuating water levels have not adversely affected the pond's overall condition, it does appear to have had a deleterious affect on the marginal macrophyte and on the macroinvertebrate communities. Sweep net sampling of the Machine Pond revealed very low numbers of macroinvertebrates. While this undoubtedly reflects the presence of only a reduced marginal flora, low water levels and exposed sediments would render the pond inhospitable for the majority of macroinvertebrate species.

The fish stocks in the Machine Pond had been investigated on two occasions prior to the present survey. In 1974, the IFT carried out a netting survey in which no fish, other than

3-spined sticklebacks, were captured. A small shoal of rudd was observed on the surface of the pond during that survey. The report concluded that the pond had excellent potential as a coarse fishery (IFT, 1974) and recommendations were made to stock the pond with perch and tench. A survey conducted by the ERFB in 1987 revealed a stock of mainly rudd and a small emerging roach population. No tench were recorded during the survey (ERFB, 1987).

The fish stock assessment operation conducted in 2007 revealed a population of roach and perch in the pond. It appears that the roach population is in a healthy state, exhibiting no obvious negative effects from fluctuating water levels and with growth rates above average, in comparison to UK standards (Cowx, 2001). Results show that, on average, a 14cm roach was 4+ years old in this pond. By comparison, a 14cm long roach in the Island Pond was 6+ years old. No perch had been recorded in this pond prior to the present survey and it is probable that they were introduced following recommendations by the IFT in 1974. No tench or carp were recorded or observed during the present survey, despite anecdotal evidence that carp were present in the pond.

As with the Island Pond (see Section 3.7), the rudd population appears to have disappeared from the Machine Pond. With a relatively balanced and sustainable population of roach, it is possible that inter-specific competition may have resulted in the demise of the rudd population (Caffrey & Mcloone, 2004).

3.7.4. Recommendations for future management

It will be important to remove the majority of the fallen tree and shrub material from the margins of the pond, and to selectively remove some of the overhanging vegetation, if the water body is to be developed for recreational or amenity purposes. This will allow more light to reach the pond, remove obvious obstructions to anglers and open up the pond to public viewing. Some aquatic weed control may be required to maintain the *Elodea* at manageable biomass levels.

The Machine Pond possesses many of the qualities necessary for a healthy and sustainable coarse fish population including aquatic vegetation, instream cover and refuge from predation. It is recommended that the fish populations could be augmented by the introduction of carp, tench and bream. The presence of willow roots in the water of this pond provides an additional spawning substrate and one that is particularly suited to carp. With an abundant fish stock, the Machine Pond could provide an excellent coarse angling amenity within the Phoenix Park. A number of discrete bankside fishing areas (swims) could be created by selectively clearing some of the willows and levelling these cleared areas of bankside.

3.8. GLEN POND (No. 8 – System E)

3.8.1. Introduction

The Glen Pond is situated in a picturesque valley in the western sector of the Phoenix Park (Plate 51, see Figure 1) and close to the Knockmaroon Gate. Due to its aesthetic qualities, the pond is a popular site with walkers and there are car parking facilities nearby.

Plate 51. The Glen Pond, Phoenix Park, looking north towards the inflow.

The Glen Pond has a classic on-line design and is fed by the Furry Glen Stream (Figure 34). It was not possible to establish the origin of this stream during the present survey. It enters at the north-western corner of the park and flows in an easterly direction through Farmleigh Pond (see Figure 1), before diverting south towards the Glen Pond (Plate 52 & 54). The stream continues for a further 1km south of the pond before discharging to the River Liffey.

Plate 52. Outflow from Glen Pond, Phoenix Park

At approximately 0.38 hectares, the Glen Pond is one of the larger ponds in the Phoenix Park system. It is encircled by mature deciduous trees and a path runs along its eastern edge (Figure 31). At one point in time, the pond may have been surrounded by a cast iron railing, as remnants are still visible along the eastern bank and a section of railing is still intact along the southern shore (Plate 53). The pond is close to a series of paths and roads, although the main access road is not available to public vehicles. The southern end of the pond, where the outflow is located, is dammed to accommodate the access road.

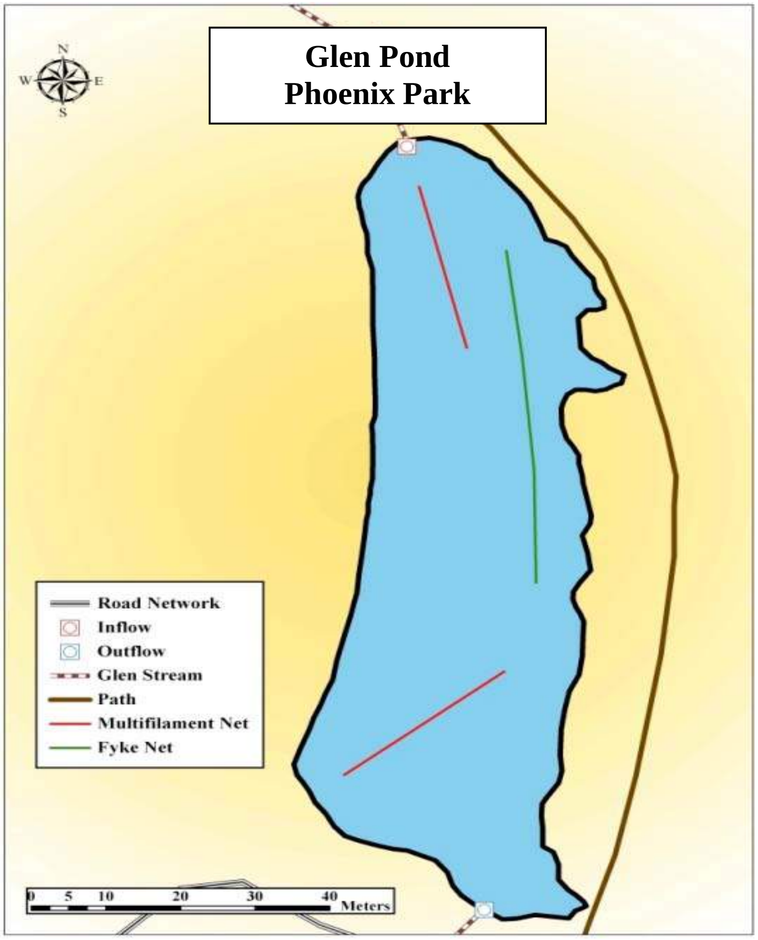

Figure 31. Map showing the position of gill and fyke nets that were set on the Glen Pond, Phoenix Park, in 2007.

Plate 53. View of the Glen Pond, Phoenix Park, from the southern bank, showing the remnant of the metal railing.

Over the past 30 years, the Glen Pond has been the focus of several fish stock surveys. In 1974, the IFT examined the pond's potential for fishery development, while a similar survey by the ERFB was conducted in 1987. The Glen Pond is a popular angling location for the general public in the area.

Plate 54. View of the Glen Pond, Phoenix Park, from northern bank.

3.8.2. Results

(a) Bathymetry

The bathymetry of the Glen Pond reflects its on-line design, with shallow water in the vicinity of the inflow and a gradual deepening of the pond towards the outflow on the southern shore (Figure 32). A maximum depth of 5m was recorded at the southern end of the pond. The mean depth at the time of the survey, in June 2007, was 2m.

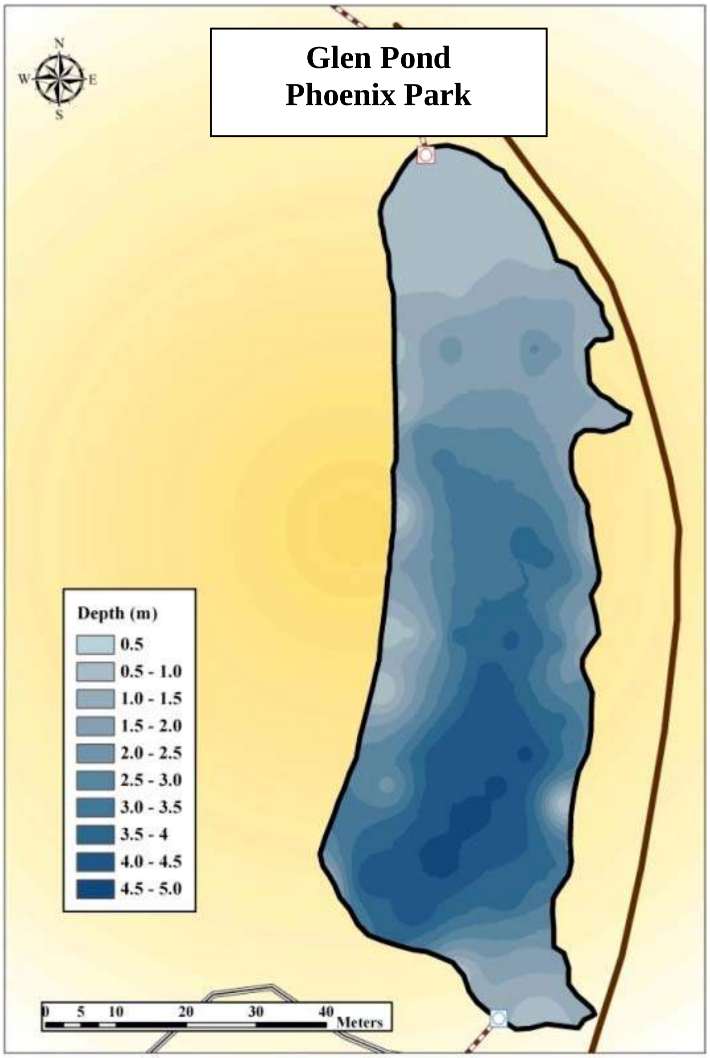

Figure 32. Bathymetric profile of Glen Pond, Phoenix Park, recorded in June 2007.

(b) Water quality

Water temperatures in the Glen Pond reached a high of 21°C in June, dropping to 15.9°C in October. Conductivity ranged from 402µS/cm to 468µS/cm, while Alkalinity values were between 5.041meq/l and 5.129meq/l, indicating hard water (Table 17 & Appendix I). Water clarity was relatively good in this pond during the survey and Secchi depths to 2m were commonly recorded. However, water samples revealed somewhat elevated levels of chlorophyll, particularly near the inflow point, where a reading of 60µg/l was reported in June (Table 17).

Table 17. Physico-chemical data recorded from the Glen Pond, during 2007. Results in red indicate breaches in parameters (see Table 1).

Maxhine Pond Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Inflow	June 07	0.194	0.148	<0.049	468	5.041	60	144.5	27.2	21
Mid - lake	June 07	0.164	0.121	<0.049	456	5.063	34.2	250	80.2	20.3
Outflow	June 07	0.148	0.112	<0.049	448	5.085	25.8	150	<1	20.1
Inflow	Oct. 07	0.238	0.221	0.385	402	5.107	28.3	160	<1	16.1
Outflow	Oct. 07	0.232	0.087	0.338	412	5.129	21.6	148.5	27.2	15.9

Nutrient analyses showed that the water in the pond had a high phosphorus content, with the highest TP value almost four times greater than the recommended guideline of 0.063mg/l. Correspondingly, the highest MRP value was over ten times greater than the limit of 0.02mg/l, above which eutrophication might be expected. Elevated phosphorus levels in the Glen Pond are probably a result of both external and internal nutrient loading. The high chlorophyll reading at the inflow in June suggests that nutrients are entering the pond *via* the Glen Stream. It is also likely that phosphorus release from sediments and decaying organic matter is contributing to the elevated levels. Bacteriological sampling of the water column revealed very low counts of total and faecal coliforms in the Glen Pond.

(c) Macrophytes

Tall deciduous trees are a feature of the glen in which this pond is situated. The perimeter of the pond is more or less surrounded by this tall vegetation (Plates 51, 52 and 54). In places, particularly along the steeply sloping western bank, a dense shade is cast on the water by this tall and overhanging canopy. This shade significantly restricts the development of marginal, emergent macrophytes in this area. Elsewhere, the margins were well vegetated. The principal species present were Yellow flag (*Iris pseudacorus*) and Reed sweet-grass (*Glyceria maxima*). The former plant grew with considerable abundance along the margins and into the water to a depth of *circa* 0.3m at the shallow, northern end of the pond. During the summer, the bright yellow flowers produced by this plant added to the aesthetics of this attractive pond. The *Glyceria* stands were also locally abundant and provided sanctuary for the large number of waterfowl that regularly visit the pond. This vegetation also encroached into the pond, in places up to 4m from the pond edge.

Plate 55. Grapnel haul showing an abundant submerged flora in the Glen Pond, Phoenix Park, during summer 2007.

A number of relatively low-growing fringing herb species were present along these margins also. These formed discrete stands but also grew in mixed assemblage. They added diversity and character to the pond margins. The species present included Water mint (*Mentha aquatica*), Water forget-me-not (*Myosotis scorpioides*), Water-cress (*Nasturtium aquaticum*) and Brooklime (*Veronica beccabunga*) (Appendix II).

The floating leaved macrophyte community was dominated by Yellow water-lily (*Nuphar lutea*), which occupied *circa* 15% surface cover of the pond during the summer months. In the deeper sections of the pond, the conspicuous floating leaves and emergent yellow flowers of *Nuphar* formed a relatively thin strip (2m wide) along the margins (Plate 56, 57). Small free-floating mats of Common duckweed (*Lemna minor*) were present among the marginal and floating-leaved vegetation.

The submerged macrophyte flora was dominated by two species, the rooted Canadian pondweed (*Elodea canadensis*) and the free-floating Blanketweed (*Cladophora* sp. (cf. *glomerata*) (Plate 55). Other filamentous algae were also present, but with less abundance than *Cladophora*. Most prominent among these, particularly close to the inflow, was *Spirogyra intestinalis*. Both *Elodea* and *Cladophora* are pollution tolerant species and both can grow in shaded situations. Their prominence in the Glen Pond, therefore, is not unexpected. Dense stands of *Elodea* formed a reasonably distinct vegetation band around the lake margins, often occupying the zone beneath and beyond the floating leaves of *N. lutea* (Plate 57).

Plate 56. Aquatic vegetation in the Glen Pond, Phoenix Park.

The submerged *Elodea* stands were commonly carpeted with tangled mats of *Cladophora*. This filamentous alga also grew beyond the *Elodea* zone and created a thin dark-green carpet on the deep mud bed of the pond. Occasional tall-growing stands of Lesser pondweed (*Potamogeton pusillus*) were observed breaking the water surface towards the northern end of the pond (Appendix II).

Plate 57. Large band of *Elodea canadensis* is present beneath and outside the band of *Nuphar lutea* along the margins of the Glen Pond, Phoenix Park, in 2007.

(d) Macroinvertebrates

The macroinvertebrate community of the Glen Pond included large numbers of the Freshwater louse (*Asellus aquaticus*), Water boatmen (Corixidae sp.) and numerous mollusc species (Appendix III). The highest numbers of individuals were recorded in a sweep sample of exposed sediments overlain with patches of filamentous algae.

Molluscs were particularly abundant in this sample, especially the gastropods *Bithynia tentaculata*, *B. leachii*, the White Ramshorn (*Planorbis albus*) and the bivalve *Sphaerium* sp. In fact, molluscs were a prominent constituent of the invertebrate community as a whole and one species, the Bladder snail (*Physa fontinalis,* Plate 58) did not occur in any of the other ponds. In the dense stands of *Glyceria fluitans*, Corixidae, *B. leachii* and *A. aquaticus* were the most commonly occurring species.

Plate 58. The Bladder Snail (*Physa fontinalis*), as recorded from the Glen Pond Phoenix Park, in 2007.

Overall, the macroinvertebrate fauna recorded in the Glen Pond belong to families that have a high tolerance for organic pollution, which probably reflects the nutrient-rich conditions therein. Insects were scarce and only one species of mayfly nymph (*Cloeon dipterum*) and a single cased caddisfly (*Mystacides longicornis*) was recorded.

(c) Fish

Three species of fish were recorded in the Glen Pond. Roach were the most numerous species, comprising 50% of the total number of fish captured (Figure 33).

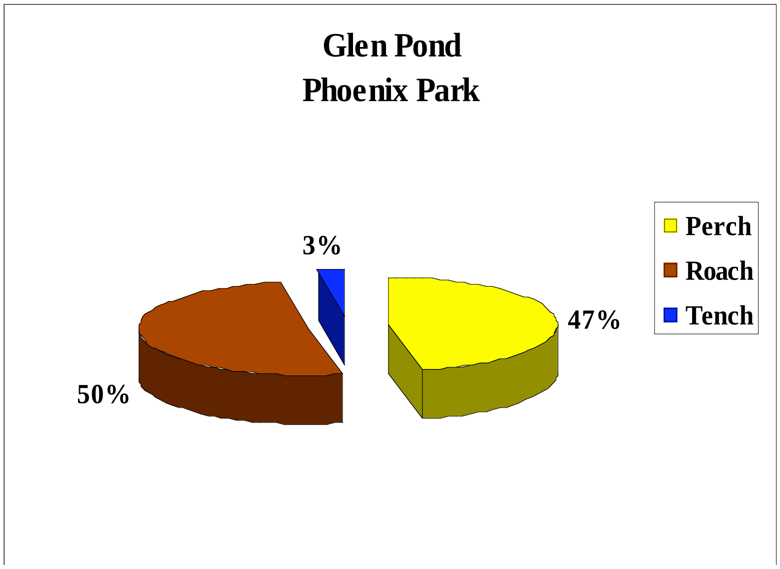

Figure 33. Relative representation of each fish species captured in the Glen Pond in June 2007.

The fish ranged from 5 to 24cm in fork length and from 8 to 287g in weight. A reasonably high CPUE of 16 was recorded (Table 18). A total of seven roach were captured during the electro-fishing operation.

Table 18. Catch Per Unit Effort (CPUE), mean length and weights of species captured during survey of Glen Pond in June 2007.

	No.	CPUE	Length (cm)	Weight (g)
Roach	39	16	17.4 5-24	165 8-287
Perch	36	14	16.4 8-29	92 9-429
Tench	2	1	26 25-27	325 274-377

The length frequency data indicated a well balanced population of roach, dominated by two distinct size groups (5 to 8cm and 17 to 21cm) (Figure 34). The roach within these two size categories were aged 3+ to 4+ and 6+ to 8+ years old, respectively. Comparisons with standard UK growth rates (Cowx, 2001) revealed an average growth rate for this population (see Appendix IV).

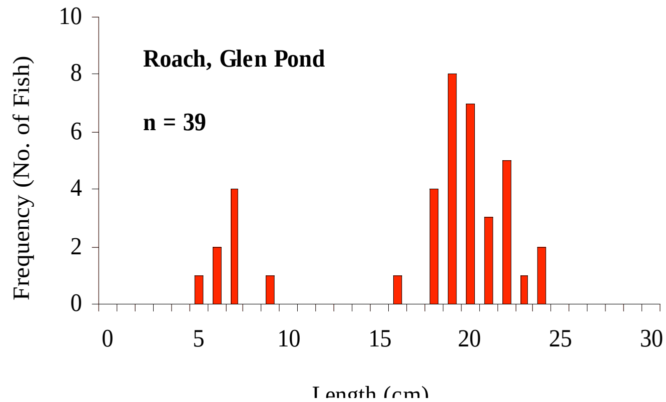

Figure 34. Length frequency distribution of roach captured in the Glen Pond, Phoenix Park, in June 2007.

Perch comprised 47% of the total number of fish captured in the Glen Pond (Figure 33). Specimens captured ranged from 8 to 29cm in fork length and 9 to 429g in weight (Table 18, Plate 59).

Plate 59. Perch of 29cm and 429g recorded from Glen Pond, Phoenix Park in 2007.

A total of eight perch were captured during the electro-fishing operation. While it was not possible to age the perch by scale analysis, the length frequency data revealed a relatively balanced population, with many fish in the 13 to 18cm size range. Younger fish that will recruit to this size category were also present, as were older and larger specimens (Figure 35).

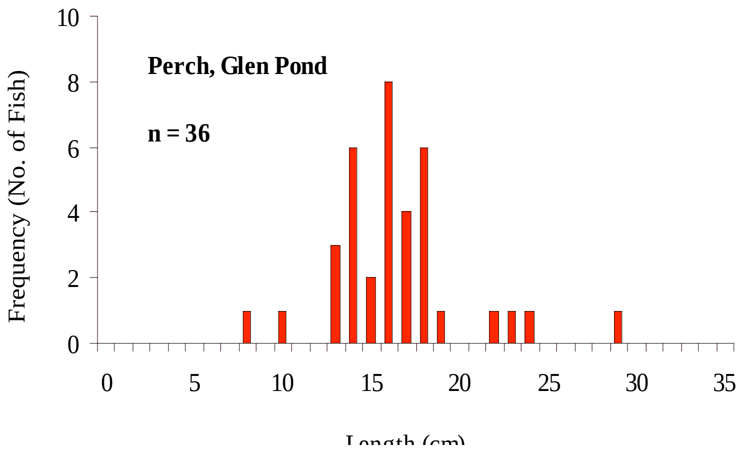

Figure 35. Length frequency distribution of perch captured in the Glen Pond, Phoenix Park in June 2007.

Tench represented 3% of the total fish captured in the Glen Pond (Figure 33). The fish were 25 and 27cm in fork length and 274 and 377g in weight (Table 18).

Plate 60. Male tench (25cm, 274g) captured during the fish stock survey of the Glen Pond, Phoenix Park, in 2007.

The two specimens were identified as being male and female, respectively. Age analysis revealed that the male tench (Plate 60) was 6+ and the female tench was 7+ years old (Appendix IV).

3.8.3. Discussion

The Glen Pond is situated in one of the most scenic areas of the Phoenix Park and, of all the ponds surveyed, it has the greatest aesthetic appeal. It is an alkaline, productive water with a high phosphorus content. The pond is surrounded by mature deciduous trees and it supports a relatively diverse aquatic flora and fauna.

Water chemistry samples taken in June and October revealed high levels of TP and MRP in the pond. While internal loading from sediment and decaying leaf litter is likely to be an important factor, a high chlorophyll reading at the inflow in June suggests the influence of nutrient inputs from the Glen Stream. The pond supports a varied aquatic flora and a number of emergent, submerged and floating-leaved macrophyte species were recorded. Macroinvertebrate sampling found high numbers of crustaceans (*Asellus aquaticus*), water boatmen and numerous bivalve and gastropod snails. Snails require an adequate supply of calcium carbonate for their shells. The geology of the park is predominantly calcarious carbonific limestone. It is likely that the Glen Stream, from its contact with the underlying bedrock, provides a source of calcium carbonate to the pond and the snail population is availing of this resource. This is reflected in the moderately high alkalinity values recorded.

Fish stock assessments of the Glen Pond were carried out on two previous occasions, in 1974 (IFT) and 1987 (ERFB). No fish were captured during either survey but both reports identify the pond as having excellent potential as a coarse fishery. The IFT report recommended stocking the pond with tench, while the ERFB suggested the establishment of a trout fishery.

The fish survey carried out in 2007 revealed the presence of three species of fish, namely roach, perch and tench. The origin of these fish is unknown, but length frequency data for the roach and perch indicates that they represent reasonably healthy, self-sustaining populations. Only two tench were captured. It is possible that tench were introduced to the Glen Pond following recommendations from a previous report.

3.8.4. Recommendations

The Glen Pond is a very attractive watercourse that provides a wonderful recreational amenity in the western section of the Phoenix Park. While the pond supports a healthy flora and fauna, measures could be put in place to further enhance its visual appeal, as well as its potential as a coarse fishing amenity.

Conditions on the western shore could be improved by thinning some of the overhanging trees to allow greater light penetration. Following this, emergent macrophytes from the eastern shore could be transplanted to expedite natural bankside stabilisation and recolonisation on the currently exposed margins. It was observed during sampling that some areas of the eastern bank are heavily trampled. Marginal vegetation could be propagated in these sections by introducing bunches of staked willow at the fringes of the pond and planting the area behind with emergent plants (O' Grady, 2006).

Plate 61. Fishing stands on an artificial pond in Co. Offaly.

It is recommended that the pond is stocked with carp, tench and rudd to augment the fish populations already present in the pond. The general public already use the Glen Pond as an angling resource and the instalment of fishing stands (e.g. Plate 61) would provide a structural incentive, as well as protecting underlying banks.

3.9. MAGAZINE STREAM (No. 9 - System F)

3.9.1. Introduction

It was not possible to determine the source of the Magazine Stream during the survey. Nor was it possible to glean any reliable information on the source of the stream from the available literature. The culvert carrying the stream enters the Phoenix Park in the vicinity of the Castleknock Gate and follows the course of Chesterfield Avenue to the main intersection on this road (see Figure 1).

Plate 62. The densely overgrown Magazine Stream facing upstream towards the 15 Acres. The Magazine Fort is located to the left of the car park in the background. The stream enters a culvert underneath the metal railing in the foreground and marks the end of the survey site.

The culvert now splits, with one arm carrying water in a northerly direction towards the Island Pond. Another arm carries water towards the centre of the park and, apparently disappears at this point. A third arm runs adjacent to the 15 Acres, ultimately discharging into the River Liffey. The only open section of stream occurs on this latter arm (see Figure 1). The open section of stream occupies a channel length of *circa* 600m. The channel width varies between 0.6m at the north end of the survey site and 3m at the southern end (Plate 62, Figure 36). The channel is relatively straight and, in places, displays a moderate gradient. The substrate comprises coarse gravels, commonly carpeted with depositing silt or mud.

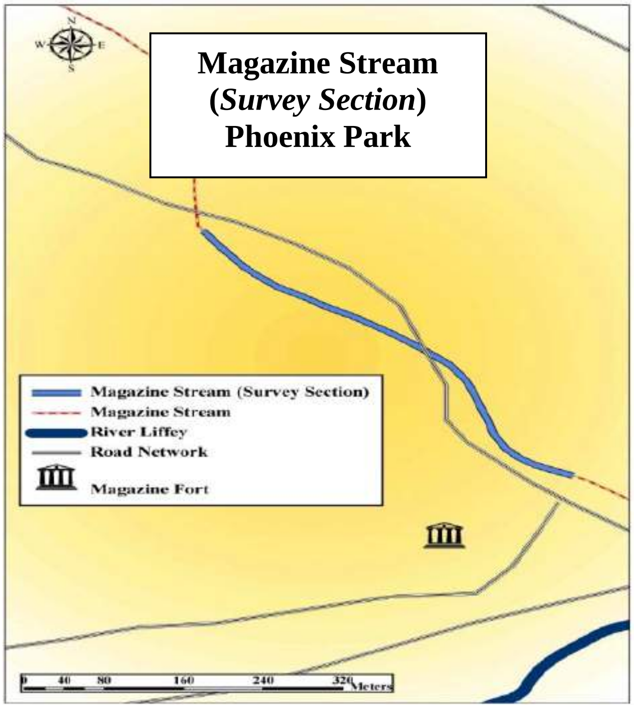

Figure 36. Map of the open channel survey section of the Magazine Stream, Phoenix Park, sampled in 2007.

Modifications, in the form of culverts and bridges, have been made to the stream over the years to facilitate the park's network of paths and roads (Plate 63 & 64a). Other physical features in the stream include a number of weirs, which were installed as a form of flood control (Plate 64b). Between June and October 2007, the open section of the Magazine Stream supported a low flow.

Plate 63. The Magazine Stream looking downstream towards the Islandbridge Gate. A culvert visible in the foreground represents the start of the open channel that was surveyed in 2007.

Water trickled through the riffles and collected in the occasional pools that were formed upstream of the concrete weirs.

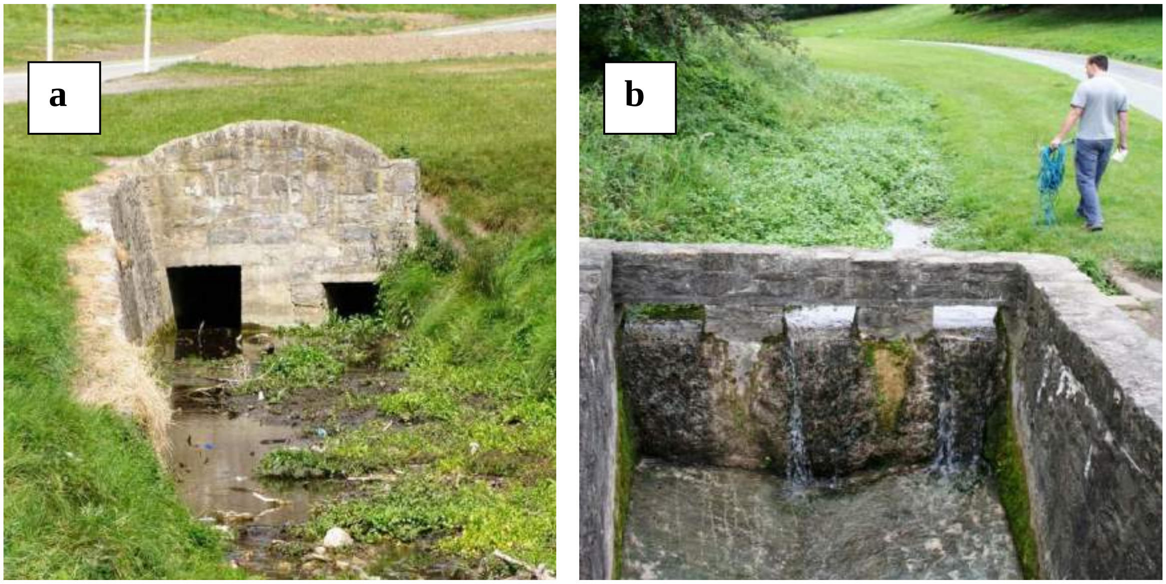

Plate 64. The Magazine stream within the Phoenix Park a) where it emerges from an underground culvert and b) at the site of a concrete weir.

The slow flow and accumulated organic silt in the stream created ideal conditions for the proliferation of emergent, fringing herb species, which totally overgrew the channel (Plates 62 & 65a). Because of the profusion of emergent vegetation, it was not possible to electro-fish the stream.

3.9.2. Results

(a) Water Quality

Water temperatures in the Magazine Stream ranged from 16.2^{o}C in June to 14.1^{o}C in October. The highest Conductivity reading of 480µS/cm was recorded during the October survey. The high Conductivity and Alkalinity readings recorded (Table 19) clearly reflect the highly alkaline nature of this stream. Low chlorophyll readings would be expected as the stream is culverted for most of its length. Molybdate Reactive Phosphate (MRP) exceeded the threshold value (0.05mg/l) on both sampling occasions (Table 19, see Appendix I). While the source of this nutrient enrichment is unknown, it is probable that the water is already enriched before it enters the Phoenix Park.

Bacteriological analysis of water samples revealed very low counts of total and faecal bacteria in the Magazine Stream.

Table 19. Physico-chemical data recorded from the Magazine Stream, during 2007. Results in red indicate breaches in parameters (see Table 1).

Magazine Stream Site	Date	Total P mg/l	MRP mg/l	TON mg/l	Cond. µS/sec	Alk. meq/l	Cphyll a µg/l	Total bacteria No. 100ml	Faecal bacteria No. 100ml	ºC
Stream	June 07	0.102	0.085	1.09	380	5.12	1.470	17.5	7.3	16.2
Stream	Oct. 07	0.086	0.08	1.259	480	5.74	2.258	17.5	7.3	14.1

(b) Macrophytes

The relatively slow flow of clear, nutrient-rich water and the open (unshaded) aspect of the Magazine Stream combined to create favourable conditions for the establishment and growth of emergent macrophytes. During the survey period (June to October 2007) the open section of stream was totally overgrown by mixed fringing herb species.

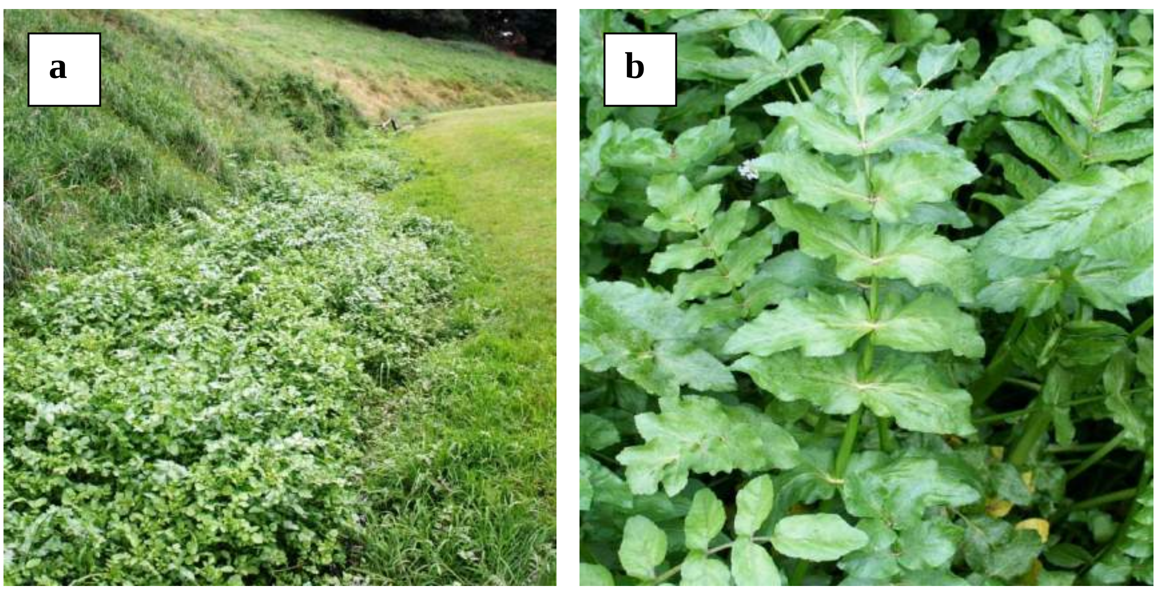

Plate 65. The Magazine Stream in the Phoenix Park, showing a) significant encroachment with emergent vegetation, and b) some of the species involved (*Apium nodiflorum*, with *Nasturtium aquaticum* in the foreground).

These plants grew luxuriantly in this non-erosive and illuminated habitat. The principal species present was Water-cress (*Nasturtium aquaticum*), although conspicuous stands of Fool’s water-cress (*Apium nodiflorum*) and Brooklime (*Veronica beccabunga*) were also present (Plate 65b). Commonly, all three species formed complex mixed assemblages within the confines of the channel. Lesser stands of Water mint (*Mentha aquatica*) and Floating sweet-grass (*Glyceria fluitans*) were also present in the stream. Along the margins, particularly in or near ponded sections of stream, tall stands of Reedmace (*Typha latifolia*) were recorded. Occasional, tall (1.2m) and expansive Water dock (*Rumex hydrolapathum*) plants occupied the channel margins.

(c) Macroinvertebrates

Benthic macroinvertebrates were collected by kick sampling sections of the gravel bed and by sweeping a net through the tall herbaceous flora. The Magazine Stream supported an array of species. These included the mayflies *Baetis rhodani* (see back cover) and *Ephemerella ignita*, and the cased caddisfly *Sericostoma personatum*, all of which are common and widespread in Ireland. Also present was the native Water shrimp *Gammarus duebeni* (Plate 66). It is noteworthy that the only freshwater shrimp recorded in the ponds during this survey was the alien species *Crangonyx pseudogracilis*. *Gammarus duebeni* is the commonest freshwater species of *Gammarus* to be found in Ireland.

Plate 66. Native water shrimp *Gammarus duebeni* recorded in the Magazine Stream, Phoenix Park, in 2007.

It has an omnivorous diet, feeding on living and dead plants, macroinvertebrates and dead fish.

(d) Fish

Because of the density of the vegetation that occupied the channel during the survey period, it was not possible to effectively net or electro-fish the watercourse. During survey work, however, numerous 3-spined sticklebacks were observed.

3.9.3. Discussion

The Magazine Stream is relatively productive, supporting an abundant aquatic flora and a diverse macroinvertebrate community, on a predominantly gravel bed. In theory, the stream should provide ideal conditions for spawning salmonids. The section of stream that was surveyed has many of the desirable attributes that a spawning area for brown trout would require. These include gradient, gravel of a suitable size for spawning, macrophytes to provide cover and a macroinvertebrate food source. Little is known about the history of the stream, although the installation of weirs and culverts (probably in the 19th century) suggests that it may have been responsible for episodic flooding in the lower sections of the park. Information provided by OPW staff suggests that the stream is spaty, rising and falling rapidly following heavy rainfall. The artificial weirs that are in place on the stream probably serve to contain the flow during spate events and to avoid flooding. During dry periods, however, these structures impede and reduce flow velocity and, in places, create relatively static, ponded conditions.

3.9.4. Recommendations for future management

The Magazine Stream is culverted between the section of open channel that was surveyed and the River Liffey. This means that brown trout from the River Liffey are unable to migrate upstream for spawning purposes. However, the open stream would be ideally suited for a small resident population of trout if certain minor works were carried out. These would involve removing or modifying some of the artificial impediments to water flow in order to ensure a constant flow of water in the channel. This flow would scour some of the silt that is present in the gravels and that provides such a favourable habitat for emergent herbaceous vegetation. It might be desirable to introduce some instream structures, such as groynes and deflectors, to direct and speed up the flow. It would also be useful to rake the existing gravels and to consider introducing new gravels.

Obviously, any stream enhancement work must be conducted in consultation with OPW engineers and the ERFB. Having completed this work, trout from the River Liffey could be captured by electro-fishing and introduced to the stream, in consultation with the ERFB.

4. DISCUSSION

The ponds are an important amenity within Phoenix Park, enhancing the recreational value of this urban landscape and providing habitat for a diversity of wildlife species from aquatic insects and plants, in addition to the park's resident waterfowl populations. While the ponds are already a focal point for walkers and anglers within the park, there is great potential for enhancing their visual and recreational appeal.

Water quality analysis showed that the ponds were highly alkaline, reflecting the limestone geology of the park. Nutrient analysis revealed that they were very productive water bodies and all, with the exception of the Áras Pond, had high phosphorus loadings. A number of factors are likely to have contributed to this nutrient loading. Most prominent among these are likely to be:

a) the release of phosphorus from anoxic sediments in the ponds,
b) the input of nutrients from the nutrient-rich feeder/supply streams within the park,
c) the decomposition of accumulated leaf litter on the bed of the ponds, and
d) the input of nutrients from resident populations of wildfowl that reside on some of the ponds, most notably the flamingos in the Upper and Lower World of Primates Pond.

Water clarity was good in the majority of ponds during the survey period, indicating the absence of algal blooms. However, the Lower World of Primates Pond in the Dublin Zoo complex experienced a dense phytoplankton bloom when sampling was carried out in October. Chlorophyll readings were correspondingly high at this time. The highly enriched condition of this pond was attributed to nutrient input from the flamingo enclosure on the western shore and, according to Dublin Zoo personnel, algal blooms are a regular feature of this water body.

The aquatic flora in the majority of the Phoenix Park Ponds is relatively restricted. Probably the most important factor affecting this is overhead shading by tall bankside trees and encroaching shrubbery. In some water bodies, such as the African Plains, the

Island, the Machine and the Glen Ponds, the level of incident light that penetrates to the pond margins and to the water surface is significantly reduced. The result is evident in the poor diversity among emergent macrophytes and also among other growth forms. The prevalence of the shade tolerant Canadian pondweed (*Elodea canadensis*) in two of these less densely shades waters (Machine and Glen Ponds) and the absence of shade sensitive species supports this observation.

Another factor that probably contributes to the poor representation of macrophytes, and particularly submerged macrophytes, is nutrient enrichment. The water body with the highest diversity among the submerged species was the Aras Pond. It is noteworthy that this was the least nutrient enriched pond that was surveyed in the park. In ponds where an abundant submerged flora was recorded (e.g. People's Garden, Dog, Machine and Glen), it is not surprising that the pollution tolerant Canadian pondweed was the principal species present (see Appendix II). The presence of small stands of the pollution sensitive Stonewort (*Chara vulgaris*) may be a fallback to earlier times, when some of the ponds were less enriched with nutrients. It suggests, however, that this, and other, ecologically valuable species might make a welcome return if the levels of phosphorus in the ponds is reduced.

Filamentous green algae were a feature of all of the ponds in the Phoenix Park. The most prolific species was Blanketweed (*Cladophora* sp. (cf. *glomerata*), an algal species that not only tolerates organic pollution but whose growth is favoured by the presence of such nutrient enrichment (Caffrey, 1985). In some waters the tangled and matted growth form of this plant threatened to smother the submerged macrophytes on which it lay.

It is noteworthy that no non-native, invasive, aquatic plant species were recorded in any of the watercourses in the Phoenix Park. These unwelcome visitors are spreading rapidly in waters throughout the country and are particularly common in artificial ponds and lakes (Caffrey, 2006). They represent a significant threat to native biodiversity and to the functional and amenity value of infested waters (Caffrey, 2007). Every effort must be made to ensure that no aquatic invasive plant species are consciously introduced to any of the watercourses in the park.

Macroinvertebrate communities in the Phoenix Park ponds were dominated by crustaceans, snails (Mollusca), water boatmen (Corixidae), leeches (Hirudinea), midge larvae (Chironomidae) and worms (Oligochaeta). It was observed that many of the crustaceans, snails and midge larvae attained a large size in several of the ponds, which most likely reflects the productive status of the waters and the high levels of nutrients. The Freshwater louse (*Asellus aquaticus*) was the most abundant invertebrate overall, being found in a range of mesohabitats from submerged and emergent macrophytes to exposed sediments and leaf litter. Molluscs were also an important constituent of the macroinvertebrate fauna, particularly where macrophytes were present. The gastropods *Bithynia tentaculata*, *B. leachii, Planorbis planorbis*, *P. albus* and the bivalves *Sphaerium* sp. and *Pisidium* spp. were recorded in very high numbers in certain ponds. Six species of leech were reported, of which *Helobdella stagnalis* was the most commonly occurring and abundant.

Overall, the diversity of macroinvertebrates was relatively low, with higher numbers of taxa occurring in ponds with a greater range of mesohabitats. Ponds that had a variety of submerged and emergent macrophyte beds provided more structural complexity and were generally found to have higher numbers of species and individuals. These included the Áras, People's Garden and Dog Ponds, in particular. Very few pollution sensitive species were recorded, which probably reflects the enriched conditions of the waters. Of the sensitive species that were present in the ponds, the cased caddisflies *Mysatcides longicornis*, *Triaenodes bicolor* and *Phryganea bipunctata* were the most notable, although all were recorded with low abundance. Only two species of mayfly were encountered, namely *Cloeon dipterum* and *Caenis horaria*. *Cloeon dipterum* (Pond olive) was recorded in all of the ponds and is characteristic of productive water bodies.

It is worth mentioning that only a single species of Freshwater shrimp (*Crangonyx pseudogracilis*) was recorded from the ponds in Phoenix Park. This species is native to

North America and its first Irish record was from a pond in Phoenix Park (Holmes, 1975). During the present survey, this non-native species was recorded from all the ponds, with the exception of the Dog Pond. Anecdotal evidence suggests it now has a widespread distribution in the inland waterways of Ireland.

Seven species of fish were recorded during fish stock assessments of the ponds in 2007. These included rudd, roach, perch, tench, eel, 3-spined stickleback and a single specimen of common goldfish. The People's Garden Pond and the Glen Pond had the greatest diversity of fish, with length-frequency data indicating balanced, self-sustaining populations in these ponds. Fish capture methods failed to detect any species of angling interest in the Dog Pond, as only 3-spined sticklebacks were recorded. A number of possible explanations were given for the absence of coarse fish in the Dog Pond, including the shallow depth regime, large fluctuations in water temperatures, excessive plant growth and possible over exploitation by anglers in previous years.

Results from fish scale reading analysis revealed variable growth rates among the fish in the Phoenix Park ponds. Healthy, self-sustaining populations of fish were recorded in ponds that had an overall good ecological status, providing adequate food sources, water quality, cover and spawning habitat for the resident fish. Some ponds, for example the Island Pond, were identified as having a poor capacity to support a viable fish population. Very small numbers of perch and roach were recorded in this pond. Growth analysis revealed that the roach were slow growing when compared to other ponds within the Phoenix Park and in relation to roach from water bodies in the UK (Appendix IV) (Cowx, 2001).

By contrast, large numbers of perch were recorded in the highly eutrophic Lower World of Primates Pond. This supports the view that the eutrophication processes can also create conditions that favour an increase in the numbers of coarse fishes. It has been noted that perch have the potential to impact significantly on the ecology of the systems into which they have been introduced, directly influencing zooplankton, macroinvertebrate and fish populations (Persson & Greenberg 1990; Tonn *et al*. 1992; Persson & Eklöv 1995).

The absence of carp from any of the ponds in the Phoenix Park was unexpected, as reports from reliable sources (e.g. Dublin Zoo staff and personnel from the Regional Fisheries Board) have indicated that they were present in the past. It is probable that older carp populations within the Dublin Zoo complex died off and that younger residents of other ponds were removed for eating or for stocking elsewhere. Carp are ideally suited to enriched ponds such as those present in the Phoenix Park and should be reintroduced under a controlled stocking programme.

5. MANAGEMENT RECOMMENDATIONS

Water	Problem	Recommendation	Benefit
Feeder Streams (Viceregal, Glen, Magazine)	• Nutrient enrichment	• Detailed water quality survey of feeder streams	• Establish extent of nutrient loading from these streams and make efforts to eliminate or reduce nutrient input to ponds
Áras Pond	• Unsightly algal scums	• Rotted Barley Straw (250kg/hectare)	• Improved water quality and more favorable conditions for growth of aquatic vegetation Improved conditions for fish. • Improved aesthetics
	• Low fish diversity	• Stock bream and tench	• Enhanced biodiversity
African Plains Pond	• Bankside shading	• Selectively trim and / or remove tall bankside trees and shrubs	• Increased light penetration to the pond
	• Reduced aquatic flora	• Transplant specific aquatic plant species	• Create habitat for macroinvertebrates and fish • Improve biodiversity
	• Low fish diversity	• Introduce carp	• Enhanced biodiversity and added visual attraction for Zoo patrons

Water	Problem	Recommendation	Benefit
World of Primates Ponds	• Bankside erosion	• Install faggots (willow bunches) • Propagate native marginal plants	• Protects banks from further erosion and increases diversity • Increased habitat for macroinvertebrates, fish and wildfowl
	• Nutrient enrichment	• Barley straw (250kg per hectare)	• Reduce algal blooms, increase aesthetic value
		• Relocation of flamingo population	• Reduced nutrient input into the pond • Reduce likelihood and intensity of algal blooms
		• Biomanipulation	• See Section 3.3.4.
		• Dredging	• See Section 3.3.4.
		• Create an artificial wetland (Possibly creating constructed reed-bed between peninsula and flamingo enclosure in the Lower Pond (see Figure 10))	• Increased filtration of excess nutrients, reducing input into main pond
	• Low fish diversity	• Introduce carp	• Enhanced biodiversity and added visual attraction for Zoo patrons

Water	Problem	Recommendation	Benefit
People's Garden Pond	• Reduced fish stock diversity	• Use resident tench population for stocking purposes	• Augment fish stocks and improve fish diversity in the other Phoenix Park Ponds
Dog Pond	• Excessive reed fringe	• Remove proportion of the reed bed	• Expose a greater area of open water, prevent from over-encroachment
	• Excessively shallow	• Localised dredging	• Create habitat and refuge for fish
	• Low fish diversity Lack of angling facilities	• Stock with carp and tench Construct a small number of angling swims	• Provide an angling watercourse Create an urban fishery in the park
Island Pond	• Excess shading	• Selectively remove and / or trim overhanging trees and shrubs	• Increase light penetration to the pond
	• Exposed banksides	• Transplant reed species	• Stabilise banksides, increase floral biodiversity and provide habitat for aquatic biota and wildlife
	• Reduced fish abundance and biodiversity	• Stock with carp, tench and rudd	• Improve biodiversity and create and angling resource
	• Eroding /trampled banks	• Install fishing stands	• Provide safe angling, • Protect bankside flora

Water	Problem	Recommendation	Benefit
Machine Pond	• Possible pollution	• Conduct detailed survey	• Remove pollution source
	• Encroachment by trees and shading	• Remove fallen debris and selective removal of encroaching trees	• Create habitat for marginal flora • Improve appearance of pond • Remove obstructions for anglers
	• Low abundance and diversity of fish	• Stock with carp, tench and bream	• Create a viable fishery
	• Few safe fishing areas (swims)	• Develop prepared swims	• Cater for safe angling
Glen Pond	• Excess shading	• Selectively remove and / or trim overhanging trees and shrubs	• Increase light penetration to the pond
	• Exposed banksides	• Transplant reed species	• Stabilise banksides, increase floral biodiversity and provide habitat for aquatic biota and wildlife
	• Reduced fish abundance and biodiversity	• Stock with rudd, tench and bream	• Improve biodiversity and create and angling resource
	• Unmanaged banksides and island	• Remove fallen trees and sunken branches	• Add to the aesthetics of this attractive pond
Magazine Stream	• Lack of suitable habitat for salmonids	• Stream enhancement work	• Create habitat for small resident population of brown trout
	• Low fish diversity	• Introduce brown trout from River Liffey	• Enhanced fish biodiversity

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Appendix I

(1) Results from nutrient analyses carried out on water samples from watercourses in the Phoenix Park in June and October 2007. Figures in red indicate breaches in euthrophication threshold levels (see Table 1).

Sample Site	System	Sampling Period	Total P mg/l	MRP mg/l	TON mg/l	Conductivity µS/cm	Alkalinity meq/l	Chlorophyll *a* µg/l	Total Bacteria No. 100ml	Faecal Bacteria No. 100ml	Temp °C
Áras Pond (Inflow)	A	Jun-07	0.017	<0.006	<0.049	602	2.235	1.474	20	<1	18.2
Áras Pond (Open)	A	Jun-07	0.024	<0.006	<0.049	589	2.034	1.52	20	<1	17.9
Áras Pond (Outflow)	A	Jun-07	0.018	<0.006	<0.049	613	2.235	1.566	220	<1	18
Áras Pond (Inflow)	A	Oct-07	0.032	<0.006	<0.049	597	3.67	1.79	20	<1	15.9
Áras Pond (Outflow)	A	Oct-07	0.033	<0.006	<0.049	606	3.87	1.704	564	<1	16.1
African Plains (Inflow)	A	Oct-07	0.117	0.056	0.051	547	2.15	14.134	700	126	16.1
African Plains (Open)	A	Oct-07	0.155	0.089	0.066	510	2.1	20.898	4719	82	16.2
African Plains (Outflow)	A	Oct-07	0.151	0.079	0.066	535	2.1	28.805	5100	170	15.9
Upper World of Primates (Inflow)	A	Oct-07	0.294	0.145	0.214	523	3.91	2.565	4989	544	15.7
Upper World of Primates (Outflow)	A	Oct-07	0.367	0.295	0.049	512	4.3	107.073	12859	8785	16
Upper World of Primates (Outflow)	A	Oct-07	0.479	0.396	0.049	531	4.1	130.826	28260	13734	16
Lower World of Primates (Inflow)	A	Oct-07	0.614	0.456	0.049	502	3.91	248.319	48380	48380	16.3
Lower World of Primates(Open)	A	Oct-07	0.606	0.542	0.049	499	4.11	228.621	12122	8560	16.2
Lower World of Primates (Outflow)	A	Oct-07	0.578	0.482	0.06	512	4.6	183.055	1962	544	16.2
People's Garden (Inflow)	A	Jun-07	0.192	0.114	0.398	381	4.6	12.056	1780	480	19.1
People's Garden (Open)	A	Jun-07	0.069	0.042	<0.049	390	4.06	4.023	1640	370	19.1
People's Garden (Outflow)	A	Jun-07	0.169	0.165	0.134	381	4.46	3.374	1580	290	19.1
Peoples Garden (Inflow)	A	Oct-07	1.099	0.153	0.09	340	4.67	56.6	1400	178	15.6
Peoples Garden (Outlet)	A	Oct-07	0.345	0.093	<0.049	335	4.73	24.2	980	150	15.3

(1) Results from nutrient analyses carried out on water samples from watercourses in the Phoenix Park in June and October 2007. Figures in red indicate breaches in euthrophication threshold levels (see Table 1).

Sample Site	System	Sampling Period	Total P mg/l	MRP mg/l	TON mg/l	Conductivity µS/cm	Alkalinity meq/l	Chlorophyll *a* µg/l	Total Bacteria No. 100ml	Faecal Bacteria No. 100ml	Temp °C
Dog Pond (Inflow)	B	Jun-07	0.028	<0.006	<0.049	170	1.45	16.642	21	<1	21
Dog Pond (Open)	B	Jun-07	0.054	<0.006	<0.049	167	1.5	14.2	24	<1	23.2
Dog Pond (Outflow)	B	Jun-07	0.105	0.09	<0.049	168	1.67	36.98	20	<1	21.4
Dog Pond (Inflow)	B	Oct-07	0.196	0.08	<0.049	170	1.83	14.2	42.5	<1	16.3
Dog Pond (Outflow)	B	Oct-07	0.132	<0.006	<0.049	168	1.86	16.7	32.3	<1	16.4
Island Pond (Inflow)	C	Jun-07	0.098	<0.006	<0.049	380	5.861	2.67	190	20	20.1
Island Pond (Open)	C	Jun-07	0.067	<0.006	<0.049	380	5.314	6.55	120	20	20.1
Island Pond (Outflow)	C	Jun-07	0.109	0.026	<0.049	368	5.908	9.82	230	60	20.1
Island Pond (Inflow)	C	Oct-07	0.12	0.048	<0.049	367	5.955	3.5	150	<1	16.1
Island Pond (Outflow)	C	Oct-07	0.111	0.07	<0.049	379	6.11	5.42	160	<1	15.6
Machine Pond (Inflow)	D	Jun-07	0.093	<0.006	0.498	409	2.99	9.533	310	<1	20
Machine Pond (Open)	D	Jun-07	0.024	<0.006	0.238	398	3.73	1.269	380	<1	19.8
Machine Pond (Outflow)	D	Jun-07	0.09	<0.006	0.128	412	3.856	1.429	100.6	30.2	20.1
Machine Pond (Inflow)	D	Oct-07	0.078	<0.006	<0.049	389	3.871	1.298	190.4	40.1	16.2
Machine Pond (Outflow)	D	Oct-07	0.08	<0.006	<0.049	381	3.473	1.436	180.6	>1	15.9
Glen Pond (Inflow)	E	Jun-07	0.194	0.148	<0.049	468	5.041	60	144.5	27.2	21
Glen Pond (Open)	E	Jun-07	0.164	0.121	<0.049	456	5.063	34.2	250	80.2	20.3
Glen Pond (Outflow)	E	Jun-07	0.148	0.112	<0.049	448	5.085	25.8	150	<1	20.1
Glen Pond (Inflow)	E	Oct-07	0.238	0.221	0.385	402	5.107	28.3	160	<1	16.1
Glen Pond (Outflow)	E	Oct-07	0.232	0.087	0.338	412	5.129	21.6	148.5	27.2	15.9
Magazine Stream	F	Jun-07	0.102	0.085	1.09	380	5.12	1.47	17.5	7.3	16.2
Magazine Stream	F	Oct-07	0.086	0.08	1.259	480	5.74	2.258	17.5	7.3	14.1

(2) Classification of water quality in respect of chlorophyll a (mg l^{-1})

Trophic category	Maximum Chlorophyll (µg/l)	Annual Algal Growth	Degree of Deoxygenation	Level of Pollution	Impairment of use
Oligotrophic (O)	<8	Low	Low	Very Low	Probably none
Mesotrophic (M)	8-25	Moderate	Moderate	Low	Very little
Moderately eutrophic (m-E)	25-35	Substantial	May be high	Significant	May be appreciable
Strongly eutrophic(s-E)	35-55	High	High	Strong	Appreciable
Highly eutrophic (h-E)	55-75	High	Probably high	High	Total
Hypertrophic (H)	>75	Very high	Probably very high	Very high	Total

Appendix II

Aquatic plant species recorded in the watercourses surveyed in the Phoenix Park in 2007. The relative abundance of each species recorded (DAFOR* scale) is presented.

	Species	Áras	African Plains	World of Primates	People's Garden	Dog	Island	Machine	Glen	Magazine Stream
Emergent										
	Alisma plantago-aquatica	-	-	-	-	-	O	-	-	-
	Apium nodiflorum	F	-	-	-	-	-	-	F	F
	Mentha aquatica	F	R	-	-	-	O	F	F	F
	Mysotis scorpioides	F	-	-	-	-	-	-	F	-
	Nasturtium aquaticum	-	-	-	-	-	-	-	-	A
	Rumex hydrolapathum	-	-	-	-	-	-	-	-	R
	Veronica beccabunga	F	-	-	-	-	O	-	O	F
	Carex spp.	-	O	-	O	-	O	-	-	-
	Glyceria maxima	A	O	O	-	-	-	-	-	-
	Iris pseudacorus	F	F	O	-	O	-	-	O	-
	Juncus effusus	F	-	-	-	O	O	-	-	O
	Phalaris arundinacea	-	O	-	-	O	O	O	-	-
	Phragmites australis	-	-	-	D	-	-	-	-	-
	Sparganium erectum	A	F	O	-	-	O	-	-	-
	Typha latifolia	F	A	-	-	A	-	-	-	R
Floating-leaved										
	Gylceria fluitans	-	-	-	-	-	-	-	-	O
	Lemna minor	-	-	-	O	O	O	-	F	-
	Lemna trisulca	-	-	-	O	F	O	A	-	-
	Nuphar lutea	-	R	-	O	-	A	A	-	-
	Polygonum amphibium	F	O	-	-	F	-	-	-	-
	Potamogeton natans	-	-	-	-	-	-	F	-	-
	Sparganium emersum	-	-	-	-	O	-	F	-	-

*** D – Dominant (>70%), A – Abundant (30-70%), F – Frequent (10-30%), O – Occasional (1-10%), R – Rare (<1%)**

Aquatic plant species recorded in the watercourses surveyed in the Phoenix Park in 2007. The relative abundance of each species recorded (DAFOR* scale) is presented.

	Species	Áras	African Plains	World of Primates	People's Garden	Dog	Island	Machine	Glen	Magazine Stream
Submerged										
	Callitriche sp. (cf. *hermaph.)*	F	O	-	-	-	-	-	-	-
	Chara vulgaris	R	-	-	R	R	R	-	-	-
	Elodea canadensis	-	-	-	A	A	-	A	A	-
	Hippuris vulgaris	O	R	-	-	-	-	-	-	-
	Potamogeton crispus	-	-	-	-	F	-	-	-	-
	Potamogeton pectinatus	R	-	-	-	R	-	-	-	-
	Potamogeton pusillus	R	R	-	F	O	O	O	O	-
	Ranunculus circinatus	O	-	-	-	-	-	-	-	-
Filamentous Green Algae	*Cladophora* sp. (cf. *glom.*)	A	A	F	F	O	-	R	A	-
	Spirogyra intestinalis	O	O	O	-	-	A	-	O	-

*** D – Dominant (>70%), A – Abundant (30-70%), F – Frequent (10-30%), O – Occasional (1-10%), R – Rare (<1%)**

Appendix III

Macroinvertebrates recorded from the Áras Pond, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	324	180	30	46	580
Water slaters & Shrimps	Crangonyctidae	*Crangonyx pseudogracilis*	17	12		1	30
Hemiptera	Gerridae	Gerridae	2				2
Water Bugs	Hydrometridae	*Hydrometra stagnorum*	4				4
	Corixidae	Corixidae			2	21	23
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp	5	2	5		12
Ephemeroptera	Caenidae	*Caenis horaria*			1	10	11
Mayflies	Baetidae	*Cloeon dipterum*		1	15	7	23
Trichoptera	Leptoceridae	*Mystacides longicornis*		5	1	1	7
Caddisflies		*Triaenodes bicolor*	3				3
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*		3			3
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*	2	1	1		4
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp			1		1
Mollusca	Hydrobiidae	*Bithynia leachii*	6	5			11
Snails		*Bithynia tentaculata*	3				3
		Bithynia sp juv					
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*					
		Lymnaea sp		2			2
	Planorbidae	*Hippeutis complanata*					
		Planorbis albus					
		Planorbis planorbis	59	159	13		231
		Planorbarius corneus					
	Physidae	*Physa fontinalis*					
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata	1	10			11
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp	11	54	13	12	90
		Pisidium spp	1	23	7	113	144
Coleoptera	Dytiscidae	*Hygrotus inequalis*			2		2
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp	1		3		4
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*	1				1
	Coleoptera	Coleoptera larva		1	4		5
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*	5	1			6
Leeches		*Glossiphonia complanata*		4			4
		Helobdella stagnalis	9	9	1	8	27
		Hemiclepsis marginata					
		Theromyzon tessulatum		1			1
	Erpobdellidae	*Erpobdella octoculata*	5				5
Arachnida	Hydracarina	Hydracarina		1	1		2
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*	1				1
Diptera	Diptera	Diptera pupa	12				12
True Flies		Diptera larva	1				1
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva	13	101	1	13	128
		Chironomid pupa					
	Ceratopogonidae	Ceratopogonidae		1			1
	Dixidae	Dixidae					
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta	2	1			3
Worms							
Tricladida	Planariidae	*Polycelis spp*	10	4		1	15
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola	5				5
Springtails							

Macroinvertebrates recorded from the African Plains Pond, Phoenix Park, in October 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	24	48	63	31	166
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	3				3
Hemiptera	Gerridae	Gerridae			1		1
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae	6	3	60	51	120
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp					
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*	3		6	2	11
Trichoptera	Leptoceridae	*Mystacides longicornis*					
Caddisflies		*Triaenodes bicolor*					
	Limnephilidae	*Limnephilidae* spp juv				1	1
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*		6	8	6	20
Odonata	Coenagrionidae	*Ischnura elegans*			2	3	5
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp					
Mollusca	Hydrobiidae	*Bithynia leachii*			7	2	9
Snails		*Bithynia tentaculata*					
		Bithynia sp juv					
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*					
		Lymnaea sp					
	Planorbidae	*Hippeutis complanata*					
		Planorbis albus		1			1
		Planorbis planorbis			3	3	6
		Planorbarius corneus					
	Physidae	*Physa fontinalis*					
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata			1		1
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp	1				1
		Pisidium spp		21			21
Coleoptera	Dytiscidae	*Hygrotus inequalis*					
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp					
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva		1		2	3
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*					
Leeches		*Glossiphonia complanata*					
		Helobdella stagnalis	4	1	1	1	7
		Hemiclepsis marginata					
		Theromyzon tessulatum	2	1	1	2	6
	Erpobdellidae	*Erpobdella octoculata*		2		6	8
Arachnida	Hydracarina	Hydracarina					
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*				1	1
Diptera	Diptera	Diptera pupa					
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae		1		1	2
	Chironomidae	Chironomid larva		5	2	9	16
		Chironomid pupa					
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae					
	Tipulidae	Tipulidae		1		4	5
Oligochaeta	Oligochaeta	Oligochaeta	4		1	6	11
Worms							
Tricladida	Planariidae	*Polycelis spp*	1		1	8	10
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the World of Primates Ponds, Phoenix Park, in October 2007.

			Lower 1	Lower 2	Upper 1	Upper 2	Total
Crustacea	Asellidae	*Asellus aquaticus*	20	130	12	76	238
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	2	13	11	6	32
Hemiptera	Gerridae	Gerridae					
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae			4	8	12
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp					
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*			4	5	9
Trichoptera	Leptoceridae	*Mystacides longicornis*					
Caddisflies		*Triaenodes bicolor*					
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*					
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp					
Mollusca	Hydrobiidae	*Bithynia leachii*					
Snails		*Bithynia tentaculata*					
		Bithynia sp juv					
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*					
		Lymnaea sp					
	Planorbidae	*Hippeutis complanata*					
		Planorbis albus					
		Planorbis planorbis					
		Planorbarius corneus					
	Physidae	*Physa fontinalis*					
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata		1			1
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp					
		Pisidium spp			4		4
Coleoptera	Dytiscidae	*Hygrotus inequalis*					
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp					
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva					
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*					
Leeches		*Glossiphonia complanata*	1			1	2
		Helobdella stagnalis	18	9	24	20	71
		Hemiclepsis marginata					
		Theromyzon tessulatum	1	2	1		4
	Erpobdellidae	*Erpobdella octoculata*	1	2			3
Arachnida	Hydracarina	Hydracarina				1	1
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*					
Diptera	Diptera	Diptera pupa					
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva	1	3	29	6	39
		Chironomid pupa			2	6	8
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae					
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta	16		18	25	59
Worms							
Tricladida	Planariidae	*Polycelis spp*					
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*		7		1	8
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the People's Garden Pond, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Total
Crustacea	Asellidae	*Asellus aquaticus*	503	78	251	832
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	2		23	25
Hemiptera	Gerridae	Gerridae			3	3
Water Bugs	Hydrometridae	*Hydrometra stagnorum*				
	Corixidae	Corixidae	12	4	6	22
	Pleidae	*Plea leachi*				
	Notonectidae	*Notonecta* spp			4	4
Ephemeroptera	Caenidae	*Caenis horaria*				
Mayflies	Baetidae	*Cloeon dipterum*	6	1		7
Trichoptera	Leptoceridae	*Mystacides longicornis*	2			2
Caddisflies		*Triaenodes bicolor*				
	Limnephilidae	*Limnephilidae* spp juv				
	Phryganeidae	*Phryganea bipunctata*				
	Polycentropodidae	*Holocentropus picicornis*				
Odonata	Coenagrionidae	*Ischnura elegans*			2	2
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp				
Mollusca	Hydrobiidae	*Bithynia leachii*	2	3	9	14
Snails		*Bithynia tentaculata*	28	13	5	46
		Bithynia sp juv			97	97
		Potamopyrgus jenkinsi				
		Hydrobiidae juv			2	2
	Lymnaeidae	*Lymnaea peregra*			12	12
		Lymnaea sp				
	Planorbidae	*Hippeutis complanata*	1		1	2
		Planorbis albus	2			2
		Planorbis planorbis	1	2	11	14
		Planorbarius corneus			3	3
	Physidae	*Physa fontinalis*				
	Valvatidae	*Valvata piscinalis*	5	11		16
		Valvata cristata		1	5	6
		Valvata macrostoma		3		3
	Sphaeriidae	*Sphaerium* sp	86	33	8	127
		Pisidium spp	15	16	26	57
Coleoptera	Dytiscidae	*Hygrotus inequalis*				
Beetles		*Hydroporinae* spp				
	Haliplidae	*Haliplus* spp				
	Hydrophilidae	*Helophorus* spp			8	8
	Noteridae	*Noterus clavicornis*				
	Coleoptera	Coleoptera larva			2	2
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*			2	2
Leeches		*Glossiphonia complanata*			1	1
		Helobdella stagnalis	86	55	23	164
		Hemiclepsis marginata			2	2
		Theromyzon tessulatum			1	1
	Erpobdellidae	*Erpobdella octoculata*	1	1	16	18
Arachnida	Hydracarina	Hydracarina	3	5		8
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*			2	2
Diptera	Diptera	Diptera pupa				
True Flies		Diptera larva				
	Chaoboridae	Chaoboridae				
	Chironomidae	Chironomid larva	57	30	61	148
		Chironomid pupa	11	1	7	19
	Ceratopogonidae	Ceratopogonidae				
	Dixidae	Dixidae				
	Tipulidae	Tipulidae		1		1
Oligochaeta	Oligochaeta	Oligochaeta	40	11	12	63
Worms						
Tricladida	Planariidae	*Polycelis spp*			6	6
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*	3			3
Collembola	Collembola	Collembola				
Springtails						

Macroinvertebrates recorded from the Dog Pond, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	3	66	2	175	246
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*					
Hemiptera	Gerridae	Gerridae					
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae	8	122	317	38	485
	Pleidae	*Plea leachi*		1	1		2
	Notonectidae	*Notonecta* spp					
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*			1		1
Trichoptera	Leptoceridae	*Mystacides longicornis*			1		1
Caddisflies		*Triaenodes bicolor*					
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*					
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp					
Mollusca	Hydrobiidae	*Bithynia leachii*					
Snails		*Bithynia tentaculata*	1	3	20	5	29
		Bithynia sp juv					
		Potamopyrgus jenkinsi	1	7	3	12	23
		Hydrobiidae juv	37	210	22	102	371
	Lymnaeidae	*Lymnaea peregra*	1		1		2
		Lymnaea sp					
	Planorbidae	*Hippeutis complanata*	1	17		8	26
		Planorbis albus	1	1	115	31	148
		Planorbis planorbis					
		Planorbarius corneus		25	1	2	28
	Physidae	*Physa fontinalis*					0
	Valvatidae	*Valvata piscinalis*	1	2	9	2	14
		Valvata cristata					
		Valvata macrostoma	1	7	12		20
	Sphaeriidae	*Sphaerium* sp		99	17	162	278
		Pisidium spp	32	62	21	88	203
Coleoptera	Dytiscidae	*Hygrotus inequalis*	1	1	3	1	6
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp			1	1	2
	Hydrophilidae	*Helophorus* spp		1			1
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva	12	9	2		23
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*		1	1	4	6
Leeches		*Glossiphonia complanata*		4		16	20
		Helobdella stagnalis	3	6	1	46	56
		Hemiclepsis marginata					
		Theromyzon tessulatum	1	3	1		5
	Erpobdellidae	*Erpobdella octoculata*		1			1
Arachnida	Hydracarina	Hydracarina			2		2
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*		1			1
Diptera	Diptera	Diptera pupa		20			20
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva	3	6	9	9	27
		Chironomid pupa	1	5	1		7
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae		5			5
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta	4	56	7	10	77
Worms							
Tricladida	Planariidae	*Polycelis spp*					
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the Island Pond, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	595	33	30	150	808
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	11	7	16	43	77
Hemiptera	Gerridae	Gerridae					
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae	6	6	95	3	110
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp				7	7
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*		3	20	7	30
Trichoptera	Leptoceridae	*Mystacides longicornis*					
Caddisflies		*Triaenodes bicolor*					
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*			2	1	3
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp				3	3
Mollusca	Hydrobiidae	*Bithynia leachii*			3	2	5
Snails		*Bithynia tentaculata*			2		2
		Bithynia sp juv					
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*					
		Lymnaea sp					
	Planorbidae	*Hippeutis complanata*					
		Planorbis albus					
		Planorbis planorbis					
		Planorbarius corneus					
	Physidae	*Physa fontinalis*					
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata					
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp		1	1	1	3
		Pisidium spp					
Coleoptera	Dytiscidae	*Hygrotus inequalis*					
Beetles		*Hydroporinae* spp				1	1
	Haliplidae	*Haliplus* spp					
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva			1	1	2
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*	2		2		4
Leeches		*Glossiphonia complanata*					
		Helobdella stagnalis	25	3	2		30
		Hemiclepsis marginata					
		Theromyzon tessulatum					
	Erpobdellidae	*Erpobdella octoculata*					
Arachnida	Hydracarina	Hydracarina					
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*					
Diptera	Diptera	Diptera pupa			1		1
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva	6		3	1	10
		Chironomid pupa		4	4		8
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae					
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta	2			1	3
Worms							
Tricladida	Planariidae	*Polycelis spp*					
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the Machine Pond, Phoenix Park, in June 2007

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	21	15	12	13	61
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	20	16	12	16	64
Hemiptera	Gerridae	Gerridae					
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae	19		1	6	26
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp	2				2
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*	4		1	9	14
Trichoptera	Leptoceridae	*Mystacides longicornis*					
Caddisflies		*Triaenodes bicolor*					
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*				2	2
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp					
Mollusca	Hydrobiidae	*Bithynia leachii*					
Snails		*Bithynia tentaculata*	2				2
		Bithynia sp juv					
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*					
		Lymnaea sp					
	Planorbidae	*Hippeutis complanata*				10	10
		Planorbis albus	2				2
		Planorbis planorbis					
		Planorbarius corneus					
	Physidae	*Physa fontinalis*					
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata					
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp	2			2	4
		Pisidium spp					
Coleoptera	Dytiscidae	*Hygrotus inequalis*					
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp					
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva					
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*	2		1		3
Leeches		*Glossiphonia complanata*					
		Helobdella stagnalis	3	2	2	2	9
		Hemiclepsis marginata			1		1
		Theromyzon tessulatum					
	Erpobdellidae	*Erpobdella octoculata*			1		1
Arachnida	Hydracarina	Hydracarina					
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*					
Diptera	Diptera	Diptera pupa					
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva		1		1	2
		Chironomid pupa					
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae					
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta				4	4
Worms							
Tricladida	Planariidae	*Polycelis spp*					
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the Glen Pond, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	54	29	32	3	118
Water slaters & Shrimps	Crangoncytidae	*Crangonyx pseudogracilis*	4			5	9
Hemiptera	Gerridae	Gerridae		1			1
Water Bugs	Hydrometridae	*Hydrometra stagnorum*					
	Corixidae	Corixidae	6	68	18	2	94
	Pleidae	*Plea leachi*					
	Notonectidae	*Notonecta* spp		5	1		6
Ephemeroptera	Caenidae	*Caenis horaria*					
Mayflies	Baetidae	*Cloeon dipterum*	6	9	1		16
Trichoptera	Leptoceridae	*Mystacides longicornis*					
Caddisflies		*Triaenodes bicolor*			1		1
	Limnephilidae	*Limnephilidae* spp juv					
	Phryganeidae	*Phryganea bipunctata*					
	Polycentropodidae	*Holocentropus picicornis*					
Odonata	Coenagrionidae	*Ischnura elegans*		1			1
Damselflies & Dragonflies	Aeshnidae	*Aeshna* spp					
Mollusca	Hydrobiidae	*Bithynia leachii*	71	19	63	3	156
Snails		*Bithynia tentaculata*	30	1	9	6	46
		Bithynia sp juv	117				117
		Potamopyrgus jenkinsi					
		Hydrobiidae juv					
	Lymnaeidae	*Lymnaea peregra*	7	9	10		26
		Lymnaea sp		5	1		6
	Planorbidae	*Hippeutis complanata*	1	2			3
		Planorbis albus	115	9	9		133
		Planorbis planorbis	1				1
		Planorbarius corneus					
	Physidae	*Physa fontinalis*	1	10	22		33
	Valvatidae	*Valvata piscinalis*					
		Valvata cristata	13	3			16
		Valvata macrostoma					
	Sphaeriidae	*Sphaerium* sp	84	4		2	90
		Pisidium spp	4			1	5
Coleoptera	Dytiscidae	*Hygrotus inequalis*		1			1
Beetles		*Hydroporinae* spp					
	Haliplidae	*Haliplus* spp		1			1
	Hydrophilidae	*Helophorus* spp					
	Noteridae	*Noterus clavicornis*					
	Coleoptera	Coleoptera larva		1			1
Hirudinea	Glossiphoniidae	*Glossiphonia heteroclita*					
Leeches		*Glossiphonia complanata*					
		Helobdella stagnalis	35				35
		Hemiclepsis marginata					
		Theromyzon tessulatum	15				15
	Erpobdellidae	*Erpobdella octoculata*			2		2
Arachnida	Hydracarina	Hydracarina	1				1
Spiders & Water mites	Argyronetidae	*Argyroneta aquatica*					
Diptera	Diptera	Diptera pupa					
True Flies		Diptera larva					
	Chaoboridae	Chaoboridae					
	Chironomidae	Chironomid larva					
		Chironomid pupa		1			1
	Ceratopogonidae	Ceratopogonidae					
	Dixidae	Dixidae					
	Tipulidae	Tipulidae					
Oligochaeta	Oligochaeta	Oligochaeta	2				2
Worms							
Tricladida	Planariidae	*Polycelis spp*	11				11
Flatworms	Dendrocoelidae	*Dendrocoelum lacteum*					
Collembola	Collembola	Collembola					
Springtails							

Macroinvertebrates recorded from the Magazine Stream, Phoenix Park, in June 2007.

			Sample 1	Sample 2	Sample 3	Sample 4	Total
Crustacea	Asellidae	*Asellus aquaticus*	21	14	10	56	101
Water slaters & Shrimps	Gammaridae	*Gammarus duebeni*	2	3		10	15
Hemiptera	Gerridae	*Gerris gibbifer*			1		1
Water Bugs							
Ephemeroptera	Baetidae	*Baetis rhodani*	12	6		3	21
Mayflies	Ephemerellidae	*Ephemerella ignita*	3			1	4
Trichoptera	Limnephilidae	*Limnephilus lunatus*			1	3	4
Caddisflies	Sericostomadidae	*Sericostoma personatum*	2				2
Odonata	Coenagrionidae	*Ischnura elegans*			1		1
Damselflies & Dragonflies							
Mollusca	Lymnaeidae	*Lymnaea palustris*			2	1	3
Snails	Planorbidae	*Planorbis carinatus*			1		1
		Planorbarius corneus			1		1
	Valvatidae	*Valvata cristata*			1		1
	Sphaeriidae	*Sphaerium* sp		1			1
		Pisidium spp			7		7
Coleoptera	Chrysomelidae	Chrysomelidae			1		1
Beetles	Hydrophilidae	*Helophorus* spp			5		5
	Coleoptera	Coleoptera larva			1	3	4
Hirudinea	Glossiphoniidae	*Helobdella stagnalis*		2	1	2	5
Leeches		*Glossiphonia complanata*		1	5	1	7
	Erpobdellidae	*Erpobdella octoculata*		1			1
Diptera	Diptera	Diptera pupa				1	1
True Flies	Simulidae	Simulidae larva				1	1
	Tipulidae	Tipulidae	3				3
	Chironomidae	Chironomid larva			1		1
Arachnida	Argyronetidae	*Argyroneta aquatica*			1		1
Spiders & Water mites							
Oligochaeta	Oligochaeta	Oligochaeta	5	15	2		22
Worms							

Appendix IV

(1) Description of fish species present in the ponds of the Phoenix Park

RUDD *Scardinius erythrophthalmus*
Cleft of mouth directed obliquely upwards; dorsal fin small, its origin well behind insertion of pelvic fins. Anal fin short, with 10-13 branched rays. 39-44 scales along lateral line. Young fish are blue and silver; large fish are green-backed, with a golden lustre on the sides. Dorsal fin is reddish-brown while the pelvic, anal and tail fins are red in colour.
Irish Record: 2.041 kg

ROACH (*Rutilus rutilus)*

Mouth inferior; dorsal fin noticeably large, with its origin over the insertion of the pelvic fins. Anal fin short, with 9-12 branched rays (excluding the unbranched ray at the leading edge of the fin and the short rays fused with it). 40-46 scales along lateral line. Blue on the back, silvery on the sides (sometimes with a bronze lustre in big fish). The dorsal fin is brownish red while the pelvics, anal and tail fins are red. Now spreading through most major river and lake systems.
Irish Record: 1.425 kg

PERCH (*Perca fluviatilis)*
Two dorsal fins set close together, the first with sharp spines. Spines also present in the origin of the anal and pelvic fins. Greenish-olive, with black bars on the sides; pelvics, anal and tail fin are red or orange in colour.
Irish Record: 2.495 kg

TENCH (*Tinca tinca*)

A thick-set fish with strong fins. Dorsal fin short, rounded, tail fin only slightly concave. In adult males the pelvic fins are very large, *spoon shaped,* with greatly thickened anterior rays. A pair of minute barbels are attached to mouth. Greenish olive with orange-red eyes.
Irish Record: 3.697 kg

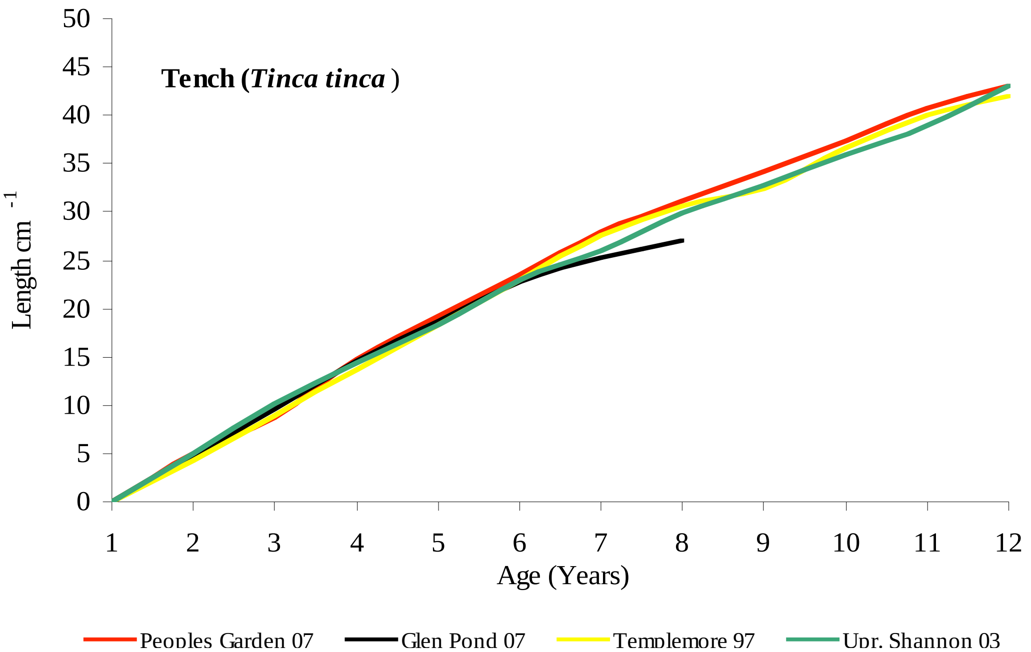
EEL *Anguilla anguilla*

Dorsal, anal and tail fins are continuous. The dorsal fin begins well behind the pectorals. There are no pelvic fins. The mouth is small, with the lower jaw being the longer. Growing eels are greenish-olive on the back, yellowish on the sides and have a small eye. Mature eels, when ready to migrate to the sea for spawning purposes (and subsequently die), become dark on the back and silvery on the sides, and the eye becomes much bigger.
Irish Record: 3.147 kg

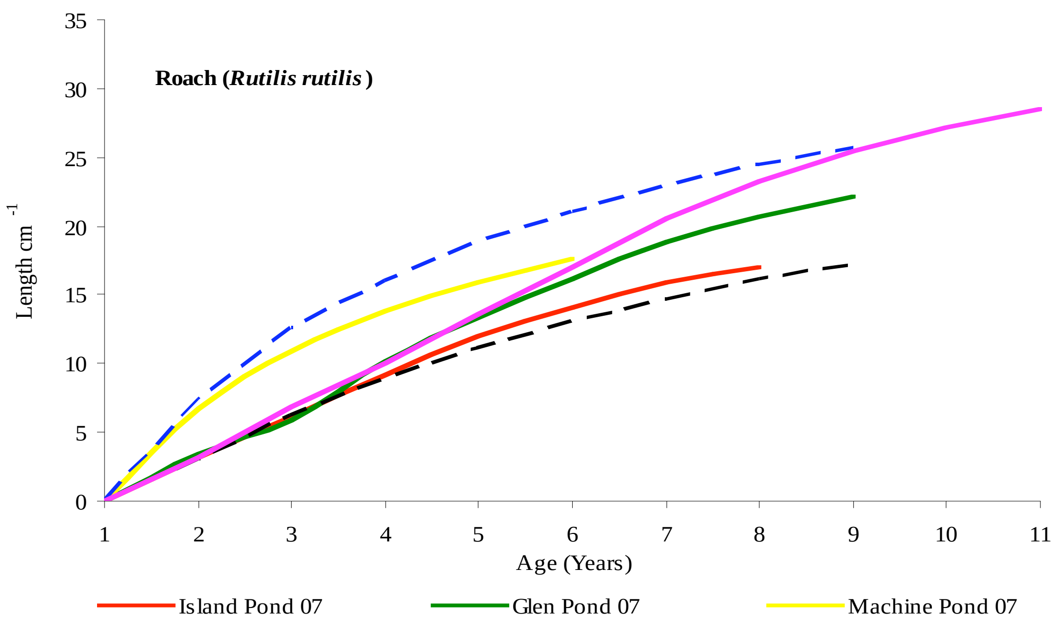
(2) Fish species present in each of the waters surveyed in the Phoenix Park in 2007.

Phoenix Park 2007	Rudd	Tench	Perch	Roach	Eel	Stickleback	Goldfish
Áras	●						
African Plains	●						
Upper World of Primates Pond			●				
Lower World of Primates Pond	●	●	●		●		
People's Garden Pond	●	●	●		●		●
Dog Pond						●	
Island Pond			●	●			
Machine Pond			●	●			
Glen Pond		●	●	●			
Magazine Stream						●	

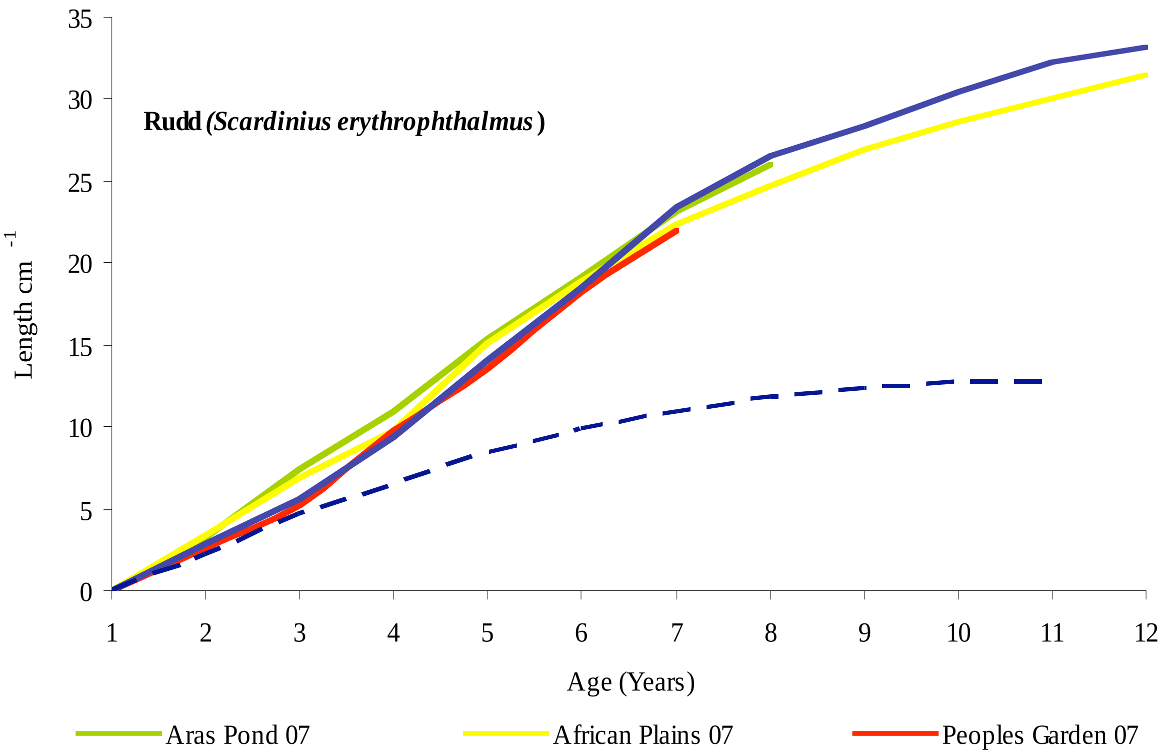
(3) Age Analysis



(i) Relative length-age growth rates of tench (*Tinca tinca*) from the Glen Pond (n = 2) and People's Garden Pond (n = 34), compared with rates recorded for tench in Irish lakes (Templemore, 1997) and rivers (Upper Shannon, 2003).



(ii) Relative length-age growth rate of roach (*Rutilus rutilus*) from the Glen Pond (n = 10), Island Pond (n = 8) and Machine Pond (n = 10), compared with rates recorded for roach from larger Irish waters such as Lough Sheelin surveyed in UK averages as calculated by Cowx (2001).



(iii) Relative length-age growth rates of rudd (*Scardinius erythrophthalmus*) from the Áras Pond (n = 24), People's Garden Pond (n = 10) and African Plains Pond (n = 9) in 2007, compared with the rate recorded for rudd in Coosan Lough (1974) and in Dalkey Pond (1974) (Kennedy and Fitzmaurice, 1974).

Central Fisheries Board
An Príomh-Bhord Iascaigh

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