

# Lake Management Group: Final Report July 2011

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# 1. Introduction and Aims

## 1.1 Scope

The International Lake Restoration Group seeks to determine the state of Lake Durowskie and its environs. It is the further goal of the Lake Management Team to determine workable solutions in order to sustainably manage the lake and others in the catchment area. From previous years' data,<sup>1</sup> the Lake Restoration group is aware of widespread contamination and expect that several lakes in the catchment area have further deteriorated. Lake Durowskie, already in bad condition, is not as likely as other lakes to receive a demoted ecological status. Lake Grylewskie is very likely to receive a demotion due to intensive agricultural runoff. Lastly, Lake Kobyleckie had a moderate level of contamination but has since received untreated sewage and is likely to be demoted. Agriculture, the intensive use of fertilizers, and sewage are likely to have decreased the ecological status of the catchment area as a whole. By identifying and analyzing the problems, stakeholders, and associated issues, the Lake Management Group has produced workable solutions for the worsening ecological status of Wagrowiec.

## 1.2 Strategic Plan for Wagrowiec

The long-term development plan for the town of Wagrowiec emphasizes modernization of town infrastructure and expansion of the tourism and recreation sectors. The Wagrowiec Mayor's office has provided numerous examples for development projects around the town, including:<sup>2</sup>

- Renovation of the lake side promenade
- Creation of a kayak-only lake zone
- Construction of a golf course, beach volleyball courts, badminton, and new tennis courts
- New cross country trails around the lake
- Establishment of picnic areas
- New lakeside viewpoints
- Organization of tourist buses
- Upgrades of eco-friendly infrastructure, such as recycling and water quality improvement programs

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<sup>1</sup> Borysiak, Janina, "Wstępny raport oddziaływania na środowisko dla zbadania inwestycyjnego „Zbiornik Laskownica” Gm. Gołańcz, pow. Wągrowiec, Woj. Wielkopolskie." Poznan 2005.

<sup>2</sup> Town Hall of Wagrowiec, "Investment Offer Wagrowiec, Poland."

- Upgrades to transportation links between Poznan and Wagrowiec
- Increase number of parking spaces
- Ecological restoration of “green areas” of the city
- New lakeside hotel adjacent to the Aquapark
- New rest and relaxation center centered around the town’s historic monastery

### 1.3 Water framework directive

The Water Framework Directive (WFD) was implemented in June 2000 and stands as the European Union’s water policy sustainability objectives. Each EU member state is responsible for its own policy in order to meet the minimum water management standards. The WFD requires a River Basin Management Plan to be implemented. This has yet to occur in Poland, where seven regional Water Boards without central coordination organize water management.<sup>3</sup>



Map 1: Regional level water regions of Poland (Source: Łukasz Legutko, Water Management Office )

<sup>3</sup> Netherlands Ministry of Economic Affairs, Agriculture and Innovation. “Introduction of the Water Framework Directive in Poland (WFD),” 2003.

## *1.4 State of the Lake Durowski 2011*

### 1.4.1 Water Parameters

#### **1.4.1.1 Hydrological Balances**

- pH values are linked to primary production and mostly higher at the Kobyleckie measurement points
- After the “rainy days”, the discharge decreases very quickly
- The loads depend very strongly on the discharge
- The concentration increases in between the 2 first sampling points > lake Kobyleckie (the shorelines) feeds the water with nutrients.
- we assume, that there are not many interactions /changes in river Golanieka (outflow K.= inflow D.)
- The P & N concentration at all station indicate eutrophic situations
- Considering the sum of the load concentration going into lake Durowskie, Durowskie acts like a sink for nutrients

Source: Hydrological Balance Group, Lake Durowski, 2011

#### **1.4.1.2 Physical Chemistry Parameters**

- The ecological state of water is improving, especially oxygen concentration and conductivity.
- Now, the most important thing is to reduce loads of nutrients incoming from catchment area, and keep recultivation activities on proper level.
- The lake is on a good way to satisfy the Water Framework Directive

Source: Physical Chemistry Group, Lake Durowski, 2011

### 1.4.2. Live in Water

#### **1.4.2.1 Algae: phytoplankton and periphyton communities**

- Comparing to 2010:
- The number of species increased
- Cyanoprokaryota species decreased
- Mixed phytoplankton index better than last year in most stations

- *Hildenbrandia rivularis* distribution increases constantly
- Water transparency is increased by biomanipulation with carnivorous fish (pike), that leads to a Phytoplankton Communities consisting of big, spiny and colony developing algae.
- Oxygen conditions on the lake have improved (more number of species which prefer very well oxygenated waters)
  
- However the overall water quality has decreased in lake Durowskie according to the Diatom Index (decreased in all Stations)
- Reasons could be:
  - unusual seasonal Weather patterns
  - additional inflowing nutrient load (Struga Gołaniecka river )
  - due to biomanipulation the ecosystem is not stable, showing huge fluctuations and dynamics

Source: Algae Group, Lake Durowski, 2011

#### 1.4.2.2 Macrophytes

1. We can observe slight increase of areas occupied by macrophytes, comparing to last year, that shows improving quality of littoral zone of the lake.
2. The associations of *Ceratophyllum demersum* characteristic for low quality waters disappeared from the lake.
3. The amount of patches of macrophyte associations appearing in clean waters like *Potamogeton perfoliatus* and *Nymphaea-Nuphar* increased.
4. We can observe increasing amount of submerged macrophytes, especially *Potamogeton perfoliatus* which indicates better water transparency.
5. The ESMI index still shows poor ecological state of the lake, however the result is higher than the one from previous years, so we can assume positive effects of restoration treatments.
6. MIR index, used for estimation of river state is a little lower, comparing to previous years, which shows bad state of water outflow from Durowskie Lake. Huge influence on state of Struga Gołaniecka has rainwater inflow from catchment area, which brings a lot of pollutants (treatment system is neglected, which causes its low effectivity).
7. We can see obvious difference in consistence of associations growing in littoral zones of northern (surrounded by forests) and southern (placed in Wągrowiec) parts of the lake. It's an evidence of different state of water in these two parts.

Macrophytes of southern part of the lake has better growing conditions, despite worst catchment area conditions.

8. Macrophyte belts growing parallel to the shoreline has very low width, which is caused by morphometry of the lake. Steep slope of the bottom is limiting growth of macrophytes, which are more dependent of water quality, especially transparency.
9. To improve state of macrophytes of Durowskie Lake we could try an introduction of other species (i.g. Characeae) from different lakes located in neighbourhood. We can also care about Kobyleckie Lake- as first treatment, use barley straws filters on inflow of Struga Gołaniecka to stop growth of *Cyanobacteria*, then introduce *Characeae*, which can survive during winter. This will provide phyto-remediators for the whole year. We can also introduce freshwater *Ulva*, which'll be great mediator during summer, because it accumulates big amount of biogens, it grows quickly and it's easy to take out of the lake. Both of these plants can be used to produce biofuels or biogases in next level of phytoremediation process.

Source: Macrophytes Group, Lake Durowski, 2011

## 2. Methods

### 2.1 Mapping

To have a better view on the Durowskie area we made in ArcGIS software the land use map. For this, we use GPS track recorded during our summer school and also satellite photography provide by ESRI. The GPS tracks ware recorded with a Garmin GPS, model Legend HCx. The projection system which we used in ArcGIS software is World Geodetic System 84 (WGS 84).

For each fishing localities (active and not active) was recorded the GPS position and a photography. The GPS points ware imported in ArcGIS software to mark the correct location and the photos ware use to quantify the damage area in to the macrophytes.

The aquatic plants layer was provided by macrophytes group in Google Earth format (KML). This was converted in shape file layer with DNR Garmin software and imported in ArcGIS software.

In the end we overlap these layers and extract the map for active and not active fishing localities.

Geomatics and the Geographic Information System (GIS) are extremely powerful, effective and helpful tools. Using data from aerial photographs and satellite images, GIS computer software can chart and analyze a given territory. By superimposing layers of information from data banks, it is possible to produce a map containing the information needed for a study. A considerable amount of information can be obtained from the map, which helps reduce the number of costly, long and detailed in-the-field studies. A GIS map shows topography, vegetation, the lakes and rivers, surface areas, roads, residences, geology, temperature, agricultural use, urban spread, status of shorelines, etc.

### 2.2 Surveys

The Environmental Management group from Poznan used surveys of tourists, hotel owners, and shop owners to gain perspectives on the town's ecological and touristic status. Three separate surveys were employed on different days to determine the activities and preferences of the community at large.

### 2.3 Investigation

Data from the above mentioned surveys were compiled to form visual representations of touristic preferences and desires. Analysis was conducted to determine relationships between tourism industry and ecology.



## 3. Results and Discussion

### 3.1 Sources of Pollution

The city of Wagrowiec and Lake Durowskie are downstream from several other lakes which, heading away from Durowskie, increase in their level of nutrient contamination. Lakes Kobyleckie, Bulkowieckie, Grylewskie, and Golancz reservoir have severe algal blooms due to eutrophication.

#### 3.1.1 Water Reserves

Construction of a dam and reservoir close to Golancz, approximately 20km north east of Wagrowiec, is expected to have a strong negative effect on the water quality of Lake Durowskie due to the dam's extremely close location to an unused municipal waste dump. Golancz has a history of polluting the river and lakes that flow into Lake Durowskie. Prior to 1999, approximately 30,000 sq. meters of waste containing elevated amounts of nitrogen, phosphate, heavy metals, and detergents overflowed.<sup>4</sup> A 1997-98 report established the Struga Golaniecka River as a receiver of sewage from factories, farms, and municipalities.

Landfills like the waste dump near Golancz contain hazardous substances from households and substances released from historical industrial activities like solvents, oil, petrol, heavy metals and sometimes radioactive substances.

#### 3.1.2 Aquaculture

Common in aquaculture operations, metabolic wastes and uneaten food are dispersed into previously oligotrophic lake water resulting in increased levels of phosphorus and nitrogen, oxygen depletion, and increased deposition of organic matter. The use of lakes for intensive aquaculture can result in a wide range of impacts like algal blooms, antibiotic resistance transfer, lake eutrophication and extensive water-quality and wildlife effects. Despite the potential for severe negative effects of aquaculture, it is not always necessary to completely remove fish farm production in order to restore ecological quality. Counteractions, such as biomanipulation or aeration can be undertaken in order to reduce damages. Algal blooms for example, can be hindered by intensive artificial aeration and circulation.

However, a whole-lake experiment conducted in Ontario, Canada shows the impacts of aquaculture on freshwater ecosystems. Total nitrogen and phosphorous concentrations increased over a 4-year period, by factors of 15 and 4, respectively. Phytoplankton biomass quadrupled annually following the start of aquaculture operation.

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<sup>4</sup> Borysiak, Janina, "Wstępny raport oddziaływania na środowisko dla zbadania inwestycyjnego „Zbiornik Laskownica” Gm. Gołańcz, pow. Wągrowiec, Woj. Wielkopolskie." Poznan 2005. Page 25.

The most dramatic responses occurred during spring and fall mixing, with blooms of chrysophytes and dinoflagellates increasing biomass by a factor of 12. The combination of a long water residence time in the lake coupled with an extremely high fish stocking density in the lake resulted in an immediate impact on water quality. The Ontario experiment clearly demonstrated the detrimental effects of aquaculture.<sup>5</sup>

Currently there are 120 hectares of fish farms operating on the lake Stawy Rybne, which flows into lake Grylewskie.<sup>6</sup> As seen in the Ontario experiment, the effects of fish farm production are cumulative; it is likely that Lake Durowskie's water quality will continue to deteriorate.

### 3.1.3 Agriculture

The Global Nature Fund asked the partner organizations of the Living Lakes network to fill in a questionnaire on the role and impacts of agriculture on the ecosystem in their lake regions. The results are of direct relevance to lake management at Lake Durowskie. Study results show (Figure1) that since agriculture is the world's largest water consumer and a major polluter of water resources, unsustainable agricultural practices threaten most Living Lakes, causing major problems such as soil degradation (61%), water withdrawal (52%), eutrophication (50 %), water pollution by pesticides (38%), and drainage & land reclamation (33%).<sup>7</sup>

Obviously agriculture necessary in many places; however, there need to be limitations placed on usage of fertilizers and pesticides in order to prevent contamination of local water bodies. Therefore, it is necessary to place restrictions on the usage and pollution of water in lake areas. Crops grown in these areas should be suited for the special site conditions and the nutrition level should be reduced.

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<sup>5</sup> Findlay, David L., Podemski, Cheryl L., Kasian, Susan E.M. "Aquaculture Impacts on the Algal and Bacterial Communities in a Small Boreal Forest Lake." *Canadian Journal of Fisheries and Aquatic Sciences*. Vol. 66, No. 11. 1 Nov. 2009. NRC Research Press. Pages 1936-1948.

<sup>6</sup> Borysiak, Janina, "Wstępny raport oddziaływania na środowisko dla zbadania inwestycyjnego „Zbiornik Laskownica” Gm. Gołańcz, pow. Wągrowiec, Woj. Wielkopolskie." Poznan 2005. Page 25.

<sup>7</sup> Global Nature Fund. "Survey on Agriculture and Lakes."

<<http://www.globalnature.org/bausteine.net/file/showfile.aspx?downaid=6364&domid=1011&fd=2>>

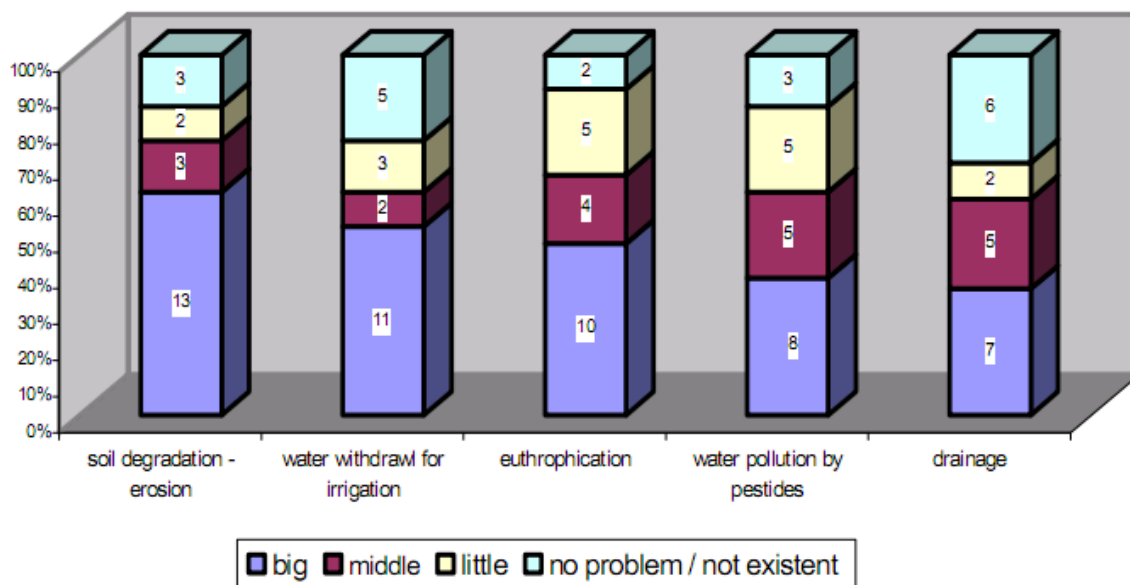


Figure 1: Problems due to Agriculture in Lake Regions (Source: Global Nature Fund)

In Wangrowicz the agricultural area represent the biggest share of all land use types, covering a total area of 24 084 ha (Table1). Most of the agricultural area is arable land, in total 20 318 ha. The close location to the lake makes this areas a potential source of nutrient load to the lake.

	ha	%
<b>Total area</b>	<b>34775</b>	<b>100,0</b>
<b>a) agriculture</b>	<b>24084</b>	<b>69,3</b>
include: arable land	20318	58,4
meadows	2210	6,4
pastures	1405	4,0
orchards	151	0,4
<b>b) forest</b>	<b>7053</b>	<b>20,3</b>
<b>c) water</b>	<b>1458</b>	<b>4,2</b>
<b>d) other</b>	<b>2180</b>	<b>6,3</b>

Table 2: Land use in Wangrowicz

## 3.2 Other Issues

### 3.2.1 Motorboats

Huge motorboats, with their strong draft and the speed at which they are operated, create waves that aggravate the erosion of shorelines and waterfronts, thereby contributing to the accelerated deterioration of water quality and wildlife habitats. Smaller boats, particularly personal water-jet-propelled craft, with only a small draft, are more easily manoeuvred in shallow water, and their use contributes to the degradation of spawning areas and other wildlife habitats along the waterfront or in the littoral zone. Yet the littoral zone is the part of a lake or river where animal and plant life is most concentrated<sup>8</sup>.

Another important fact to be kept in mind is that a considerable quantity of nutrients is locked or retained in the sediment at the lake bottom<sup>9</sup>. When watercraft operators spin their propellers or shoot their water jets in shallow water, the sediment is stirred up, and the nutrients, including phosphorus, are released into the water. They are then available to spur the growth of aquatic plants and microscopic algae.

An excessive stirring up of the lake floor by propellers and water jets significantly increases the water's turbidity, which in turn hinders the penetration of sunlight and the biochemical reactions dependent on solar energy<sup>8</sup>.

A suitable formula is available for determining the number of motorboats that a lake can support. It calculates a lake's recreational carrying capacity, not its phosphorus carrying capacity<sup>8</sup>.

The formula first requires knowing the navigable surface area of the lake, which is the total surface area less the first 60 metres from the shoreline or colonies of dense aquatic plants<sup>10</sup>.

Next, the assumption is made that each type of boat requires a certain amount of surface area to navigate<sup>11</sup>. For example, a boat equipped with a very powerful engine towing a skier would require 8 hectares, while a small sailboat would need 1 hectare<sup>10</sup>. The coefficients of occupation differ slightly, depending on the study. The occupation density will depend on the number and type of boats on the body of water.

To calculate the maximum number of motorboats a body of water can support, we can use the following equation<sup>12</sup>:

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<sup>8</sup> Fredette, P., 2007, *Lake management at the heart of development in Val-des-Monts*, Federation of Lakes of Val-des-Monts, Val-des-Monts, Québec, 143p. (including 13 app.).

<sup>9</sup> Nürnberg, G.K., LaZerte, B.D., 2004, *Modeling the effect of development on internal phosphorus load in nutrient-poor lakes*, Water Resour.Res., 40, W01105, doi:10.1029/2003WR002410.

<sup>10</sup> Horner and Associates Limited, Michalski, M., Hunter, R.W., 1995, *Lake carrying capacities and proposed shoreline development policies*, Préparé pour Municipality of the County of Kings, Truro, NS, 100p.

<sup>11</sup> Progressive, AE, 2001, *Four Township recreational carrying capacity study*, Grand Rapids, MI, 18p.

<sup>12</sup> Bosley, H.E., 2005, *Techniques for estimating boating carrying capacity: a literature review*, North Carolina State University, Raleigh, NC, 32p.

*Optimal number of boats = navigable surface area / occupation density*

We strongly think that the motorboat access on the lake should be reduced only to the southern part (Map 2).



Map 2: Boat management

### 3.2.2 Fishing localities and macrophytes implications

There are several good reasons for keeping lakeshore vegetation. Direct access to the water is not the only issue, as vegetation provides:

1. A habitat for plants and wildlife as a buffer between the land and the aquatic environments, this vegetation sustains an extraordinary diversity. Plants, fish, insects, frogs, birds, deer and many other species use this habitat at some point in their lives.
2. A barrier that prevents sediment and pollution from entering the lake The vegetation in a riparian buffer slows the runoff of water into the lake. Some of the sediment, nutrients and pollutants (fertilizer, pesticides, etc.) in runoff water are trapped, which reduces their load on the lake.
3. A safeguard against soil erosion the root systems of the plants form a mat that protects the soil. They prevent waves and rainwater runoff from eroding the waterfront.
4. For small lakes, a screen that prevents the overheating of water By shading the lake, lakeshore vegetation reduces the warming effect of sunlight. Warm water fosters the growth of algae and aquatic plants. It also repels lake trout.
5. A natural windbreak the trees growing in a riparian buffer block the wind and its eroding capacity.

Christensen (2000)<sup>13</sup> and the *Groupe technique sur les bandes de protection* (1998) have suggested that a 30-metre-wide riparian buffer covered with vegetation should be maintained to prevent negative impacts on water temperature, the contribution of sediment and nutrients, the erosion of waterfronts, and runoff.

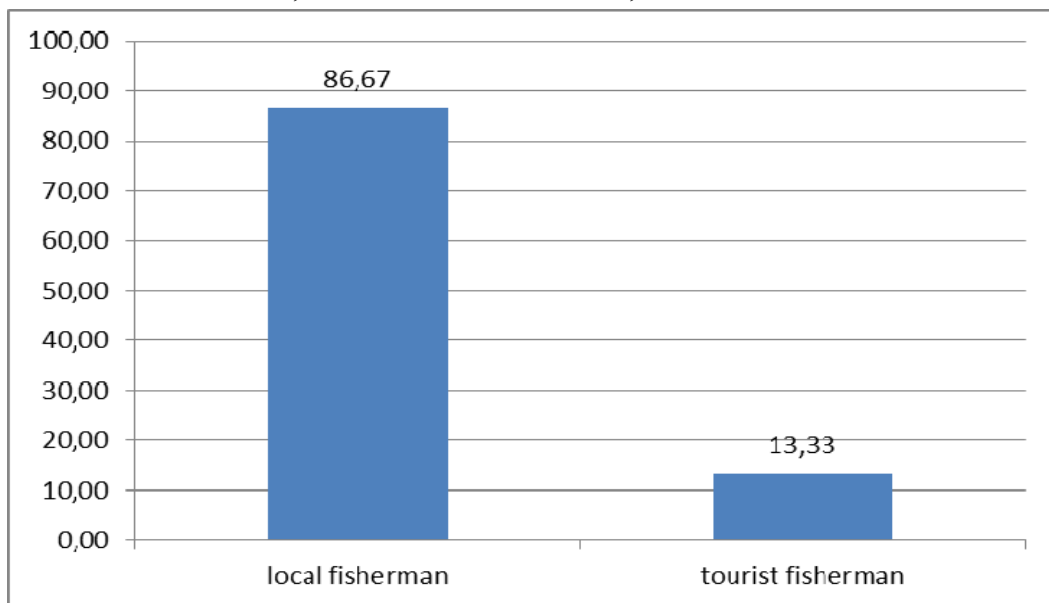


Figure 2 : Repartition of fisherman

<sup>13</sup> Christensen, D., 2000, *Protection of riparian ecosystems : a review of best available science*, Jefferson County environmental health division, Golden, CO, 15p.

Apparently most of the tourists that visit Wangrovec do that for other purposes than fishing. The fisherman (locals and tourists) catch for personal use and only very rear only for recreation. Even thou some of the fishermen feel disturbed by the tourist.

Fishing is one of the most popular recreational activities for mid age persons at Lake Durovski, classified by most participants of the survey either as acceptable or good for fishing purposes. The most abundant fish species are perch, roach and bream. This tree species constitute nearly 75% of all local species. The majority of the fishermen are from local community (86.67 %, Figure 2) fact which shows that the fishing tourism activity is not promoted.

This problem will surely increase with the number of tourists. Hence it is important to offer special fishing sites for tourist so they do not interfere with the locals.

When looking at the water quality (Figure3) most of the fishermen classified the water as a tree on a scale from one (best quality) to five (worst quality). Concerning public opinion about water quality, fishermen tend to be a good indicator, since they are the first to know if water quality changes dramatically.

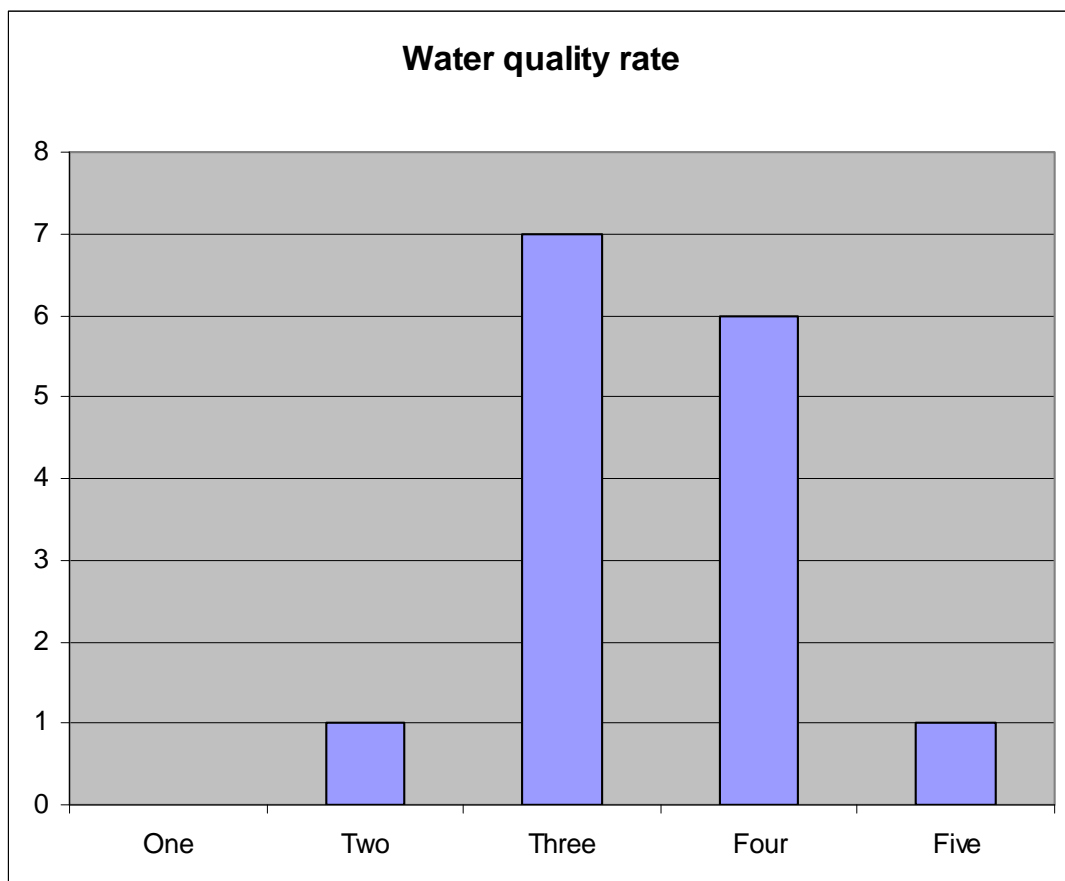


Figure 3: Water quality rate of Lake Durovskie

The fishermen ask for a lot of improvements (Figure 4) in the lake, being “better water quality” the most wanted. Another very popular demand, not only in this case but everywhere around the globe, is stocking the lake with fish. On a average scale this tends to be the first option demand of fishermen. So again it is a good indicator of low water quality that the improvement of water quality is the first option demand of the fishermen in lake Durovski.

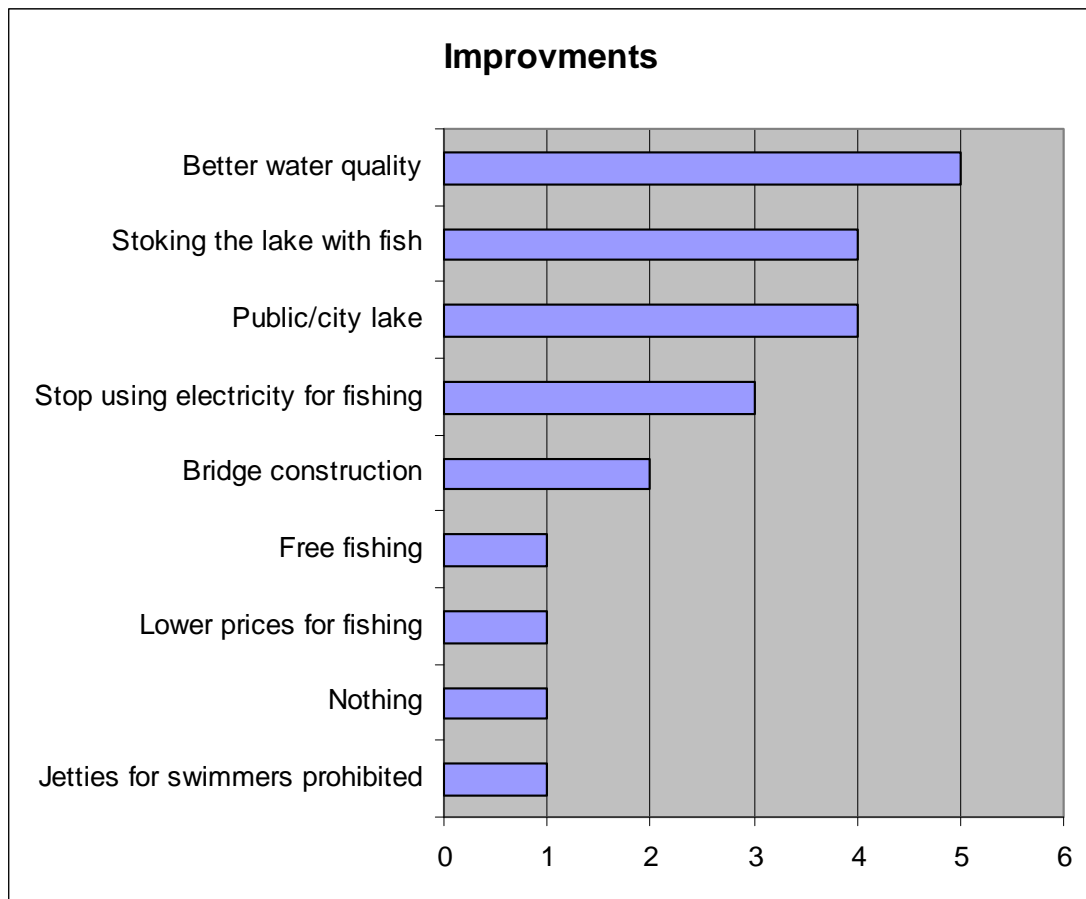


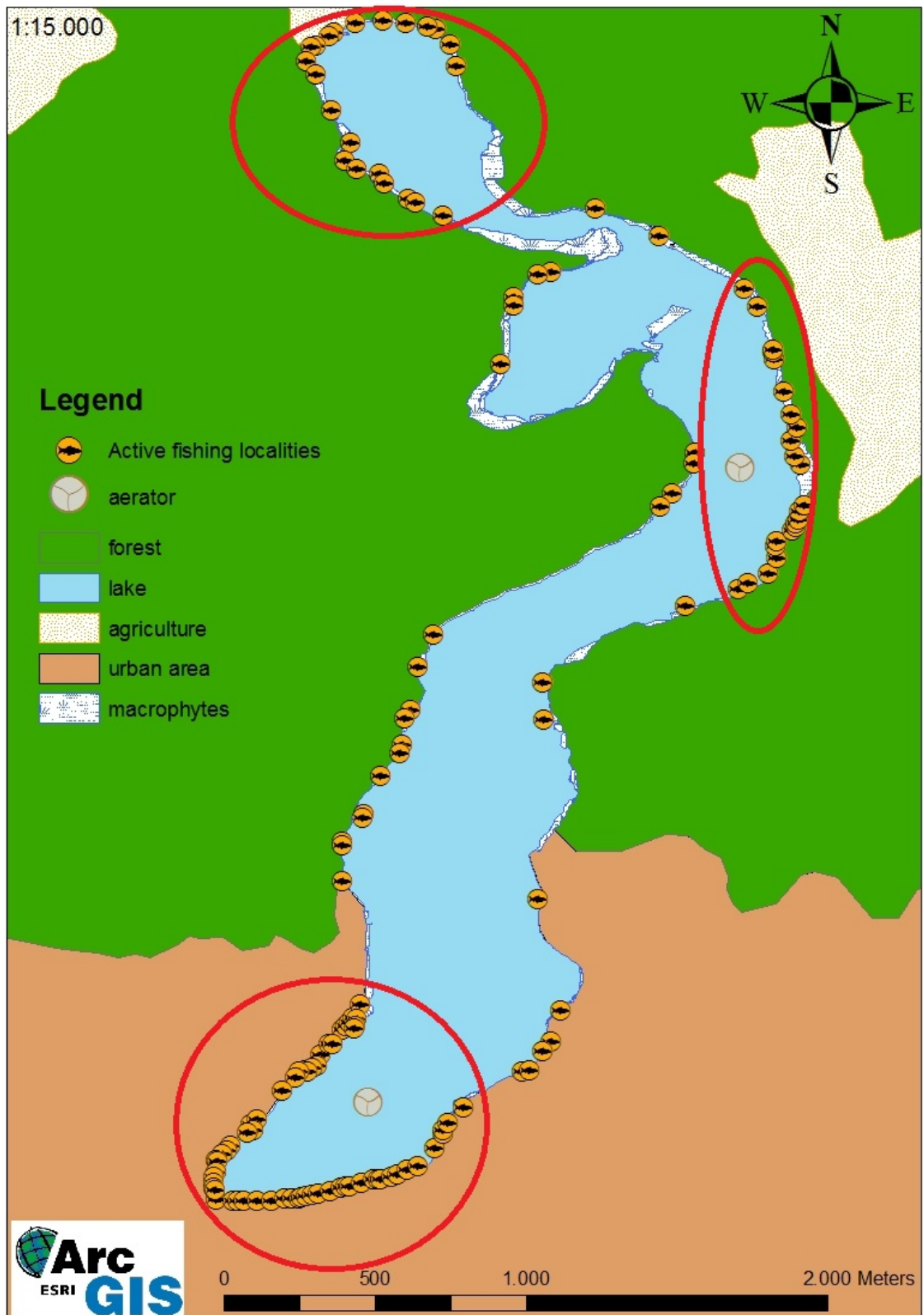
Figure 4: Improvements for Lake Durovski

We found 160 active fishing localities which cover 960 m<sup>2</sup>. From this 123 are in macrophyte which means that they destroy 738 m<sup>2</sup> (Map 3).

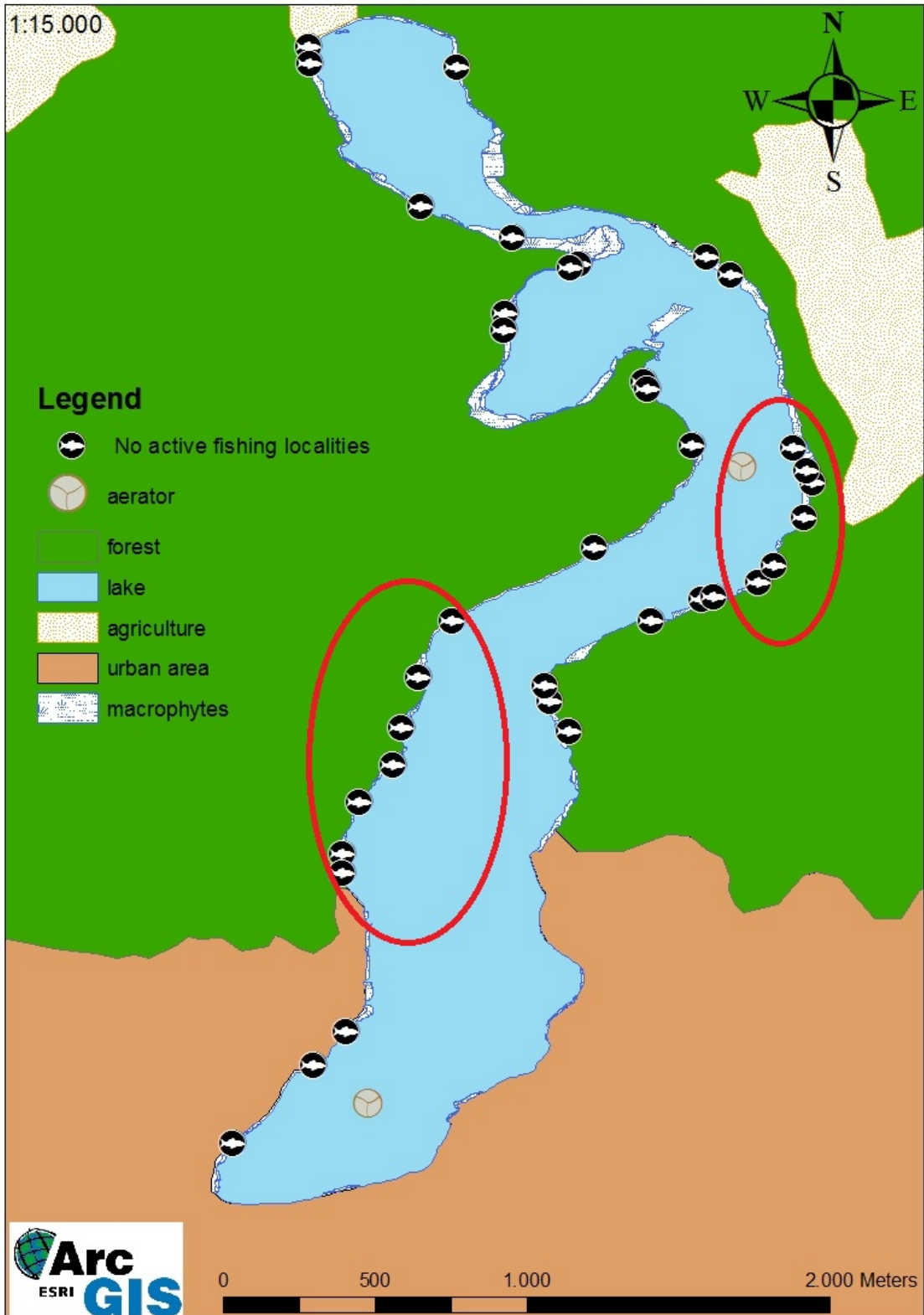
We found 37 not active fishing localities which cover 220 m<sup>2</sup>. From this 27 are in macrophyte which means that they destroy 162 m<sup>2</sup> (Map 4).

The total area of macrophytes which was destroyed by fishing localities is 900 m<sup>2</sup>. This represent 1, 33 % from the total area of macrophytes. Is not a big area but all this fishing localities fragmented the macrophytes belt.





Map 3: Active fishing localities.



Map 4: Not active fishing localities

The majority of the fishing localities are for common use (66,67, Figure 5).

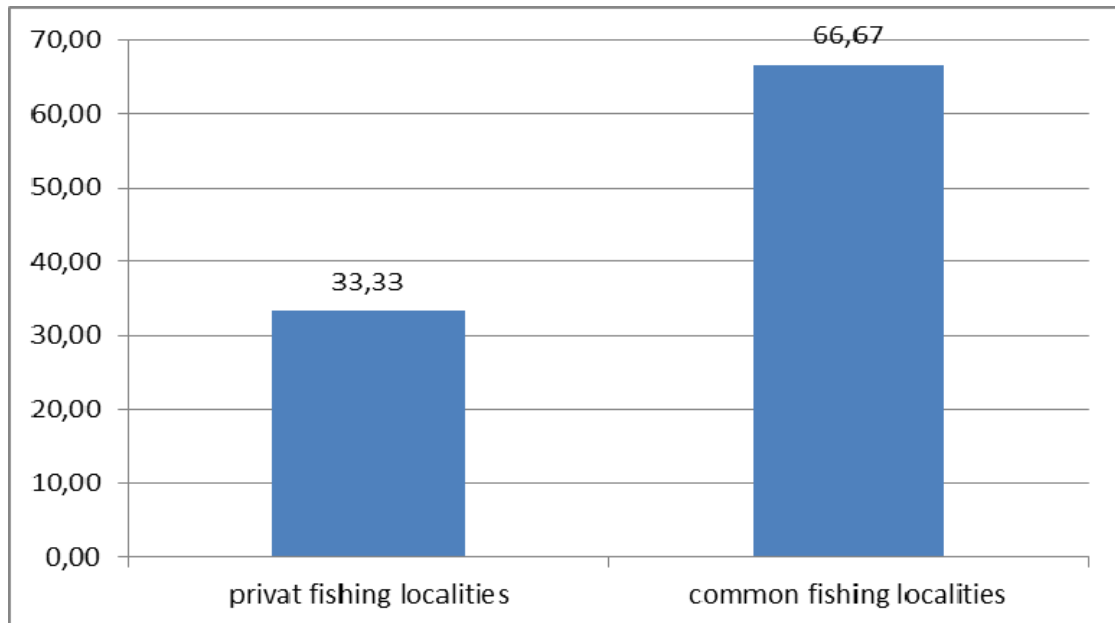


Figure 5: Fishing localities distribution

When humans clear an area next to a lake's shore and put in their own landscaping, the riparian buffer can no longer do its work effectively. If left to grow along the shore, plants, shrubs and trees can effectively and efficiently slow the runoff into the lake<sup>14</sup>. What is more, these plants use the excess phosphorus from lawn fertilizer applications and from natural sources within the watershed and thereby help prevent the nutrient enrichment of the lake.

As well, their root systems capture the nutrients carried through the soil from septic beds<sup>15</sup>. The roots also help stop soil erosion.

For new fishing localities, some techniques can be used to prevent sediment and nutrients from leaving the construction site and entering the watershed, including water runoff management, slope stabilization, sediment traps, stabilization of access roads, and containment of excavated soil<sup>16</sup>.

### 3.2.3 Forest Management

The broadleaves forest area which is near Durowskie Lake was change in last years and now the predominant species are coniferous trees. This major land use change has a marked impact on the hydrology of upland catchments with both the quantity and

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<sup>14</sup> Morin, E., 2003, *Restauration des berges et sensibilisation de la population à de bonnes pratiques en milieu riverain*, Document synthèse préparé pour le Bassin Versant Saint-Maurice, 51p.

<sup>15</sup> RAPPEL, 2005, *Rives et nature : Guide de renaturalisation*, Sherbrooke, 29p.

<sup>16</sup> RAPPEL, 2003, *Lutte à l'érosion sur les sites de construction ou de sol mis à nu; Guide des bonnes pratiques environnementales*, Sherbrooke, 29 p.

quality of surface waters being affected<sup>17</sup>. Thus, reduce water yields have been recorded as a result of increased interception losses from tall, dense conifer canopies<sup>18</sup>. Moreover, enhanced atmospheric deposition of acidic pollutants on conifer canopies has resulted in surface water acidification and the degradation of freshwater ecosystems in areas where the geology and soils have a low buffering capacity<sup>19</sup>.

The coniferous trees has the lowest quantity of base cations in the upper profile, fact which indicate that the new plantation is acidifying the soil by increased nutrient uptake and accelerated leaching<sup>20</sup>.

We strongly suggest that the coniferous forest should be replaced with natural specific forest.

### 3.3.1 Tourism

Tourism is the area of single most concern amongst the government and surveyed population of Wagrowiec. The town receives a sizeable portion of its tax revenues from tourism (the mayor's office estimates 5-7% of annual revenues), while a substantial number of its businesses are tourist based. Approximately 80% of visitors to Wagrowiec are Polish and 20% are foreign. Foreign tourists generally tended to stay at the four-star lakeside hotel.

According to survey results (n=27), Wagrowiec residents unanimously would like to see an increase in the number of foreign and Polish tourists. 97% of all respondents had a positive impression of Wagrowiec, and 89% would like to return. Their responses illustrate several surveying trends. Above all else, tourists are concerned about the quantity and quality of activities for young people. At present, concerns for water quality are seemingly secondary.

As part of their efforts to increase tourism, the government of Wagrowiec has initiated several development projects concentrating around Lake Durowskie. These projects include a new lakeside hotel, a golf course, a rest and recreation center around the local Cistercian monastery, and leasing other plots of land open to developers. Despite town proposals, survey respondents displayed mixed feelings about government efforts to procure additional tourists. Their suggestions included more youth activities, larger beaches, cleaner water, cleaner parks, more forest trails, more restaurants and bars, and better connections to Poznan. By far the majority of interviewees participate in

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<sup>17</sup> Soulsby, C. & Reynolds, B., 1995. The chemistry of throughfall, stemflow and soil water beneath oak woodland and moorland vegetation in upland Wales. *Chem. Ecol.*

<sup>18</sup> Kirby, C. Newson, M. D. & Gilman, K. (1991) Plynlimon Research: The first two decades. *Institute of Hydrology Report, Wallingford, UK.*

<sup>19</sup> Edwards, R. W., Gee, A. S. & Stoner, J. H., 1990. *Acid Waters in Wales*. Kluwer, Dordrecht, The Netherlands.

<sup>20</sup> Horner and Associates Limited, Michalski, M., Hunter, R.W., 1995, *Lake carrying capacities and proposed shoreline development policies*, Préparé pour Municipality of the County of Kings, Truro, NS, 100p.

some form of lake activities, primarily boating, but also relaxing and swimming are popular.

The large proportion of tourists to Wagrowiec who travelled from distant locations (more than 50 kilometers away) indicates that the town already enjoys success in promoting its attractiveness and opportunities for recreation and relaxation.

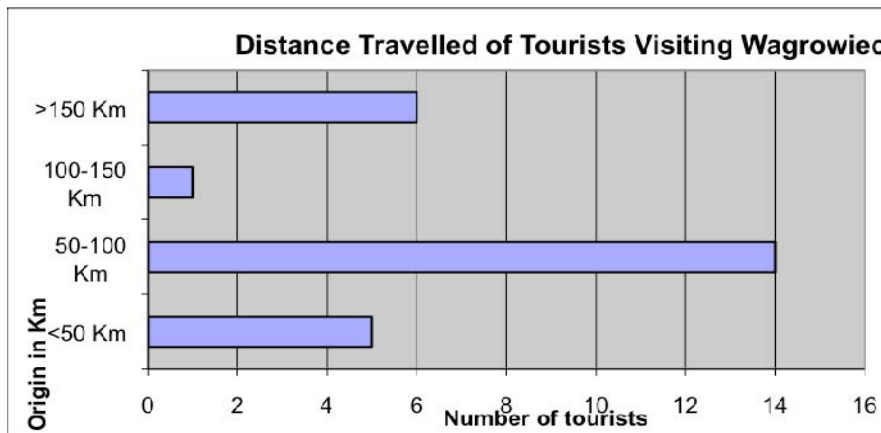


Figure 6: Survey results of tourists at Lake Durowskie

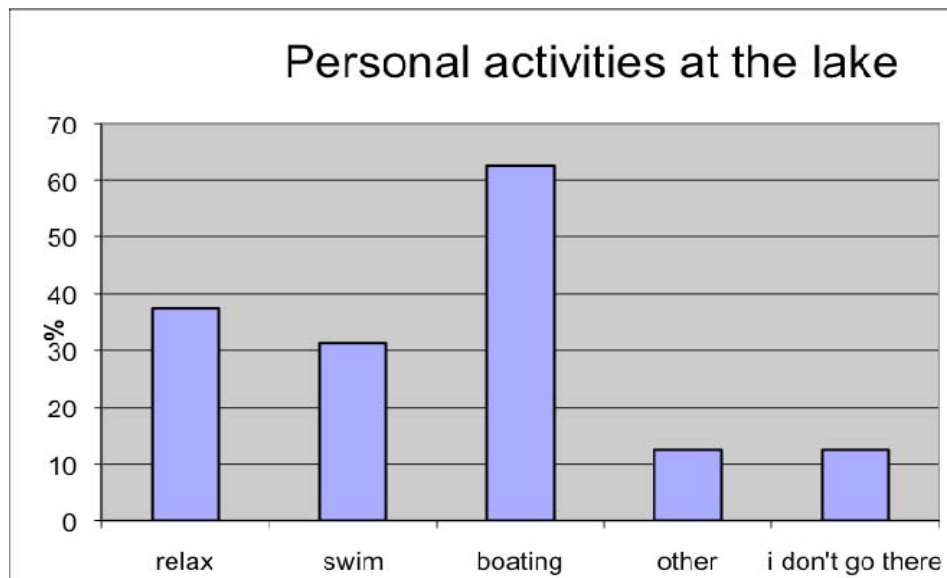


Chart 7: Survey results of tourists at Lake Durowskie

Tourism Recommendations: While the Wagrowiec government is notable in its attempts to transform the city into a tourist center, its development projects are costly and may not be effective without some more basic renovations, which have been alluded to by most tourist survey respondents. Simple changes could potentially be the most effective, such creating additional activities for young people (the primary demographic group of residents and travelers alike to Wagrowiec) or improving the quality of beaches

or increasing the number of restaurants. Large-scale development projects will probably be successful in attracting more tourists, but to retain them the town needs to improve the quality of its infrastructure while simultaneously retaining a superior ecological quality.

### 3.3.2 Hotels, Shops, and Restaurants

Wagrowiec sits in the middle of Lake Durowskie and the region around the town is rich in lakes too. This special site condition makes the town an interesting spot for investments in the touristic sector. The Wągrowiec municipal area offers another attraction: the crossing of two rivers, the Nielba and Wełna, without commingling. As shown in Figure 8, the preferred touristic spots are public places like the lake and rivers, constituting 72% of all touristic areas. Wagrowiec is a real centre of tourism, with several hotels along the shores of the lake and a variety of restaurants and shops in the town centre. Therefore the SHR-SH (Shops, Restaurants and Hotels-Stakeholders) constitute the main pillars of the touristic sector of Wagrowiec. Other touristic activities are still in the stage of development but with a considerable growth potential.

Over 70% of the SHR-SH consider that tourism has increased considerably over the last 10 years. A reason for this development is not only the lake itself but also the efforts of the tourist sector to increase the amenity-value of the town: Over 50% of all shops offer souvenirs and more than 90% offer tourist guides and additional information to their visitors.

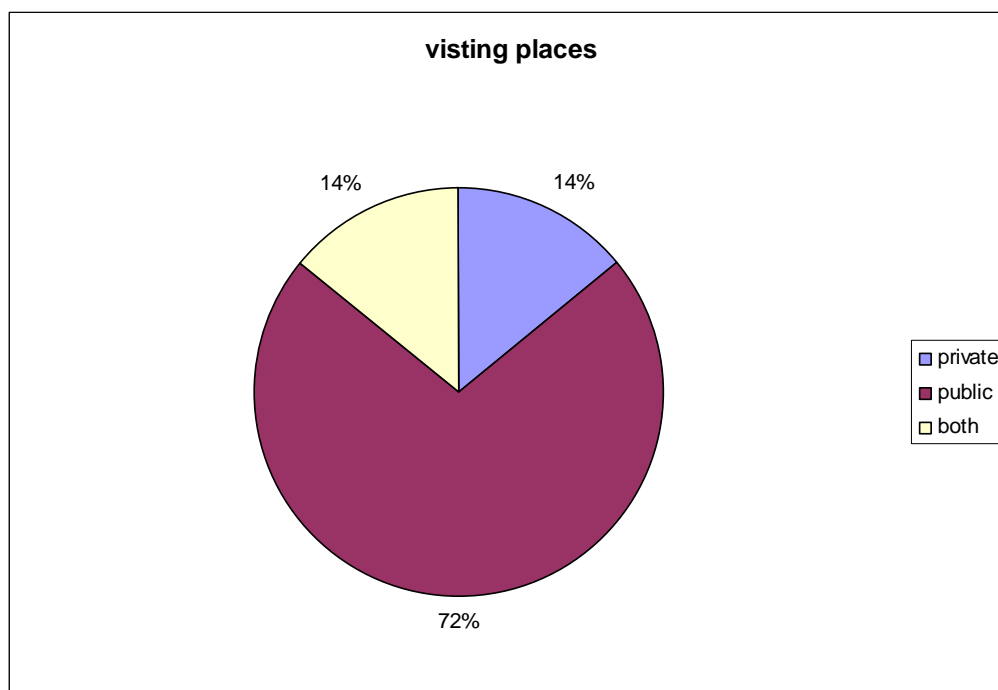
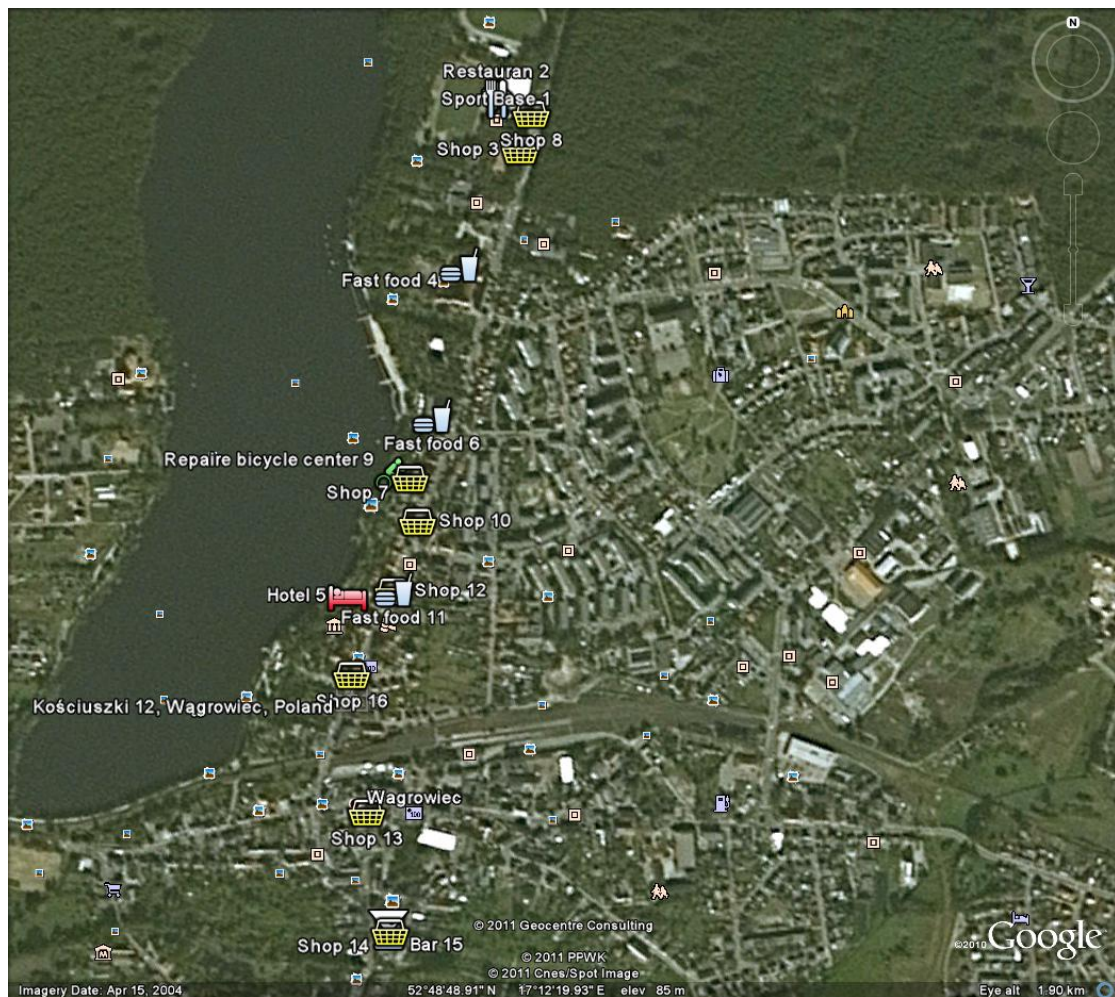


Figure 8: Touristic places





Map5: Hotels, Shops, and Restaurants in Wangrowiec

Looking at Figure 9 at the relation between the public authorities and the SHR-SH, it is shown that nearly 70% of all SHR-SH classifies the efforts of the public authority either as very good or good. Over 60% of them would be willing to pay a tourist-tax, while the rest are indifferent and no one was adamantly opposed. More than 80% consider the town as an overall good place for tourism, and worthwhile for further investment.

With increasing tourism also the income of the SHR-SH has increased. This can be confirmed by over 85% of all SHR-SH who participated in the survey. The income level could be improved even more by introducing new management strategies to adapt to the dynamic conditions of the tourism sector. Nearly no SHR-SH adapted their own price strategies, only 20% have adapted or increased their wares according to demand, and 40% already consider that the current visitor level has exceeded their touristic capacity. However nearly a 100 % of all SHR-SH would like to welcome more tourists.

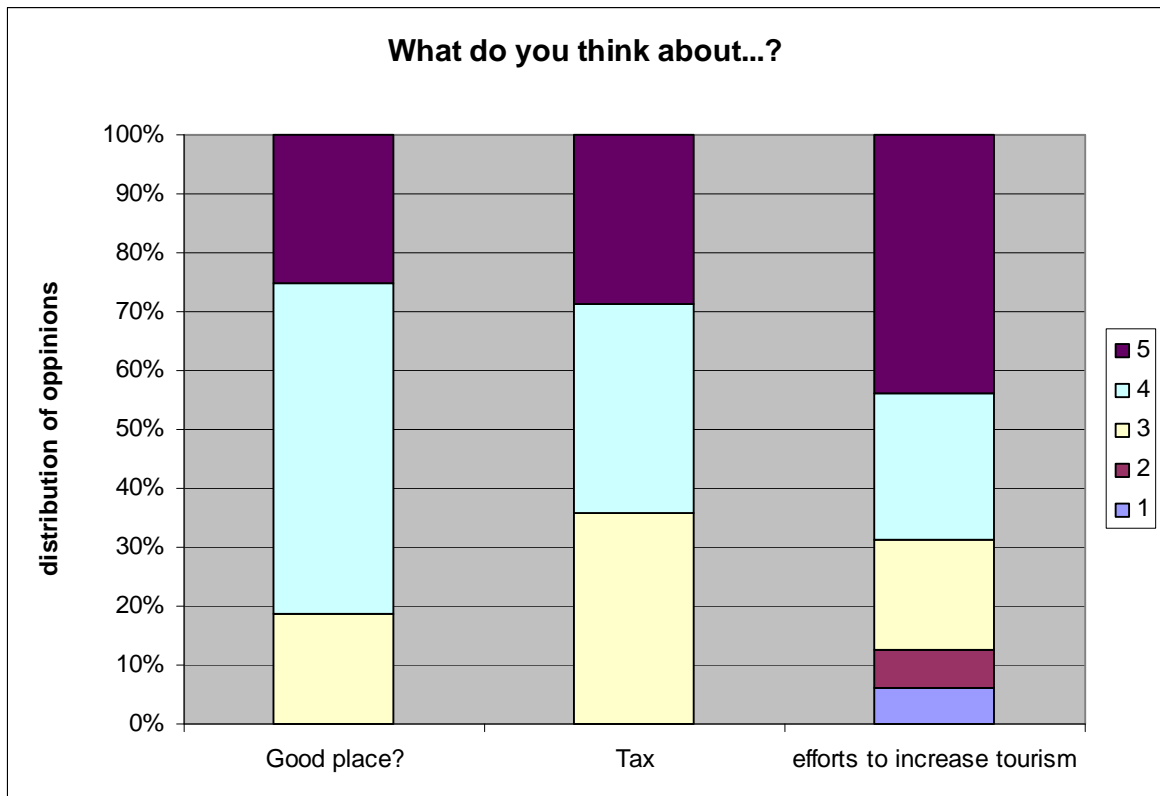


Figure 9: Relation between the public authorities and the SHR-SH

The stores and shops of Wagrowiec need to adopt progressive management strategies in order to accommodate the increasing number of tourists, in addition to considering the concept of “Ecotourism,” which would allow for the most innovative strategies to be put in place. Communication and collaboration with the city government would streamline efforts to produce eco-business policies that will have the largest effect.

### 3.3 Potentials for sustainable growth

If properly managed, the city of Wagrowiec is in a position to take advantage of eco-tourism and establish itself as a model for sustainable growth in the foreseeable future. There are, however, obstacles in the way. Mainly, the eutrophication of Lake Durowskie poses a threat to the city’s image and status as a ‘green’ town. Indeed, the challenge of decreasing environmental quality is formidable, but nevertheless not insurmountable. Specifically, by increasing public awareness of the issues and risks involved with development projects (especially construction of the Golancz area dam and reservoir, which will have an enormously detrimental effect on local water quality) and encouraging collaboration between local businesses, government, and residents, the



town will be able to grow sustainably, create new jobs, and promote an overall increase in the quality of life.

## 4 Recommendations

Overall, the Lake Management Group has been able to boil down various analyses and interpretations to reach several recommendations in order to advance sustainable growth in the city of Wagrowiec:

1. Get rid of unused jetties and allow macrophyte regrowth (ie ban swimming in certain areas) & redesign most destructive fishing areas to be more nature friendly
2. Public awareness campaign
3. Coordinate management strategies to integrate tourism and ecologically friendly practices
4. Prevent completion of the Laskowickie reservoir
5. Make special area for motor boating
6. Establishment of a national Polish Water Board, which will have enough authority to set national water policy<sup>21</sup>

If the city of Wagrowiec wants to promote its green image and improve the quality of the environment and life overall, these policies must be implemented in one form or another.

It must be kept in mind that the forecasts obtained with these models have an imprecise quality that cannot be quantified or completely eliminated. The carrying capacity models for lakes are not precise enough to determine the exact number of residences that can still be built next to them. Inversely, they cannot precisely indicate at what point there would be too many residences.

This kind of quantitative value would be difficult to defend scientifically and legally. In fact, the models are imprecise enough to prevent using them to justify denying one development in particular. In fact, from a legal point of view, someone could very well defend a new development by claiming that the residence in question will not be polluting as a good septic system will be installed, the building will be set back from the lake, etc.

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<sup>21</sup> Netherlands Ministry of Economic Affairs, Agriculture and Innovation. "Introduction of the Water Framework Directive in Poland (WFD)," 2003

Because each region has its own set of local characteristics, care must be taken to ensure that the coefficients and calculations used reflect the local reality. For example, geology and soil types differ widely among the regions. Some soil types capture and retain phosphorus more effectively than others, thereby doing more to limit the amount of phosphorus reaching the lake.

Also, the rate of occupation of secondary residences varies, depending on their distance from an urban centre and local services. The equations must be adjusted to reflect the reality of the territory and the people who live there. Monitoring lakes by means of sampling campaigns is still necessary and vital. In order to properly validate the model, calculate mobility (see below) and determine if the acceptable limit has been exceeded, we must rely on field data that has to be reliable and pluriannual.

Monitoring a lake allows for knowing its current status. Monitoring does not allow for saying what the data means as regards a lake's future state. It is here where the carrying capacity models come into play with all their advantages.

## 5. References

Borysiak, Janina, "Wstępny raport oddziaływania na środowisko dla zbadania inwestycyjnego „Zbiornik Laskownica” Gm. Gołańcz, pow. Wągrowiec, Woj. Wielkopolskie.” Poznan 2005.

Bosley, H.E., 2005, *Techniques for estimating boating carrying capacity: a literature review*, North Carolina State University, Raleigh, NC, 32p.

Christensen, D., 2000, *Protection of riparian ecosystems : a review of best available science*, Jefferson County environmental health division, Golden, CO, 15p.

Edwards, R. W., Gee, A. S. & Stoner, J. H., 1990. *Acid Waters in Wales*. Kluwer, Dordrecht, The Netherlands.

Findlay, David L., Podemski, Cheryl L., Kasian, Susan E.M. "Aquaculture Impacts on the Algal and Bacterial Communities in a Small Boreal Forest Lake." *Canadian Journal of Fisheries and Aquatic Sciences*. Vol. 66, No. 11. 1 Nov. 2009. NRC Research Press. Pages 1936-1948.

Fredette, P., 2007, *Lake management at the heart of development in Val-des-Monts*, Federation of Lakes of Val-des-Monts, Val-des-Monts, Québec, 143p. (including 13 app.).

Global Nature Fund. "Survey on Agriculture and Lakes." <<http://www.globalnature.org/bausteine.net/file/showfile.aspx?downdaid=6364&domid=1011&fd=2>>

Horner and Associates Limited, Michalski, M., Hunter, R.W., 1995, *Lake carrying capacities and proposed shoreline development policies*, Préparé pour Municipality of the County of Kings, Truro, NS, 100p.

Kirby.C. Newson.M. D. & Gilman.K., 1991. Plynlimon Research: The first two decades. *Institute of Hydrology Report, Wallingford, UK*.

Morin, E., 2003, *Restauration des berges et sensibilisation de la population à de bonnes pratiques en milieu riverain*, Document synthèse préparé pour le Bassin Versant Saint-Maurice, 51p.

Netherlands Ministry of Economic Affairs, Agriculture and Innovation. "Introduction of the Water Framework Directive in Poland (WFD)," 2003.

Nürnberg, G.K., LaZerte, B.D., 2004, *Modeling the effect of development on internal phosphorus load in nutrient-poor lakes*, Water Resour.Res., 40, W01105, doi:10.1029/2003WR002410.

Progressive, AE, 2001, *Four Township recreational carrying capacity study*, Grand Rapides, MI, 18p.

RAPPEL, 2005, *Rives et nature : Guide de renaturalisation*, Sherbrooke, 29p.

Soulsby, C. & Reynolds, B., 1995. *Hydrological impact of broadleaved forestry in the British uplands: implications for water use and water quality*. Man's Influence on Freshwater Ecosystems and Water Use (Proceedings of a Boulder Symposium, July 1995). IAHS Publ. no. 230, 1995.

RAPPEL, 2003, *Lutte à l'érosion sur les sites de construction ou de sol mis à nu; Guide des bonnes pratiques environnementales*, Sherbrooke, 29 p.

Soulsby, C. & Reynolds, B., 1995. The chemistry of throughfall, stemflow and soil water beneath oak woodland and moorland vegetation in upland Wales. *Chem. Ecol.*

6. Appendix (surveys, data, etc.)

6.1 Questionnaire fishermen

1. Are you a local fisherman or a tourist?

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2. Are the jetties/places private?

--

3. What are the prices for the fishing license?

Day	Week	Month	Year

4. Which are the major species you are fishing?

--

5. Which equipment do use?

--

6. Is there a season prohibited for fishing?

--

7. How often are you going to fish?

--

8. Do you use your catch for personal use or for sale?

--

9. Do you feel disturbed by the tourist?

1	2	3	4	5
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10. How do you rate the water quality for fishing?

1	2	3	4	5
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11. Is this a good lake for fishing (location)?

1	2	3	4	5
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12. What do you think needs to be improved?

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## 6.2 Questionnaire shops, hotels and restaurants

- 1 Where is the shop (*you have not ask for it, just note the street and number.*)
- 2 What do you sell?
- 3 What are your opening hours?
- 4 Do you recognize tourists?
- 5 Do you think that tourism increased?
- 6 Would you/did you increase the prizes because of the tourists?
- 7 Do you have any tourist's information/souvenirs here?
- 8 Do tourists increase your income?
- 9 Do you change/increase your offer because of tourists?
- 10 Do you think the city is prepared for more tourists (parking places, capacity of hostel/hospital etc.)?

### **Restaurants/Hotels**

- 1 What is the percent of polish or foreigners who rent a room here?  
 %

### **Renters**

- 1 How many: boats  or bike  do you rent in 1 season?
- 2 Which season is better for renting? (Maybe closed in winter?)

### **Personal impressions**

- 1 Do you think this is a good tourist place?  

1	2	3	4	5
---	---	---	---	---

2 What do you think about tourist tax? Are you willing to pay it?

1	2	3	4	5
---	---	---	---	---

3 Do you have the impression that the major/city is doing anything to increase tourism?

1	2	3	4	5
---	---	---	---	---

4 Do you go to the lake to do what?

relax

other

swim

I don't go to the lake

go boating

5 How often?

6 To private places, or public beaches?

7 Would you welcome more tourism in Wagrowiec?

### 6.3 Questionnaire tourists

1. Personal info:

- a) nationality:.....
- b) city: .....

2. What do you do?

- a) you are student
- b) you are worker
- c) you are retired

3. What's your main activity in free time?

- a) sport
- b) resting at the lake
- c) Aquapark
- d) restaurants, pubs
- e) stay at home

4. Are you accompanied?

- a) friend
- b) family
- c) alone

5. Why did you choose Wągrowiec?

- a) natural beauty
- b) recreation/ leisure facilities
- c) other

6. What would you improve here?

7. What was missing?

8. Did you have **positive/negative** impression?

9. Will you come back?

- a) yes
- b) no



## 6.4 Fishing localities impact

