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INTEGRATED WATERSHED MANAGEMENT: THE YARQON RIVER AUTHORITY AS A MODEL

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SUMMARY – The Yarqon River Authority (hence – YRA) was created in 1988, under the River and Springs Authority Law. The YRA, though not in charge of the whole watershed, operates on a watershed basis in many issues and the guiding philosophy is to encourage the participation of stakeholders. This was introduced by using an open, trust building process, which evolved while developing the Master Plan for the Yarqon. The planning process of the Master Plan provided the impetus for moving forward towards its implementation. The YRA's main activities involve initiating planning processes and involvement in regional and infrastructure plans and their implementation regarding projects that may influence the river and its tributaries. These activities are in the following main categories: A. Drainage and flood control, including flow modelling and flood plain management within urban settings; B. Environmental and ecological aspects related to the rehabilitation of the Yarqon, including water allocation – quality and quantity, biological issues, water reuse projects and pollution prevention; C. Recreational issues; D. Routine maintenance of the riverbed and its corridor. The Master Plan concept and its implementation can serve as a model for the rehabilitation of streams and rivers. It requires an interdisciplinary team working with stakeholders in a catchment basin framework. This requires logistical support but the results merit the effort.

Keywords: catchment basin management

1. INTRODUCTION

The Yarqon River Authority (here on – YRA) was created in 1988, under the River and Springs Authority Law. The YRA, though not in charge of the whole watershed, operates on a watershed basis in many issues and the guiding philosophy is to encourage participation of its members and stakeholders in planning and policy making of stream rehabilitation and maintenance. This was introduced by using an open, trust building process, which evolved while developing the Master Plan for the Yarqon. The planning process provided the impetus for moving forward towards its implementation and the framework is in the form of an interdisciplinary team put together by the YRA that works with the stakeholders in the catchment basin. This approach can serve as a model for the rehabilitation of streams and rivers.

1.1. The state of the coastal streams

Prior to the establishment of the State of Israel (1948) many of its coastal streams had significant perennial lotic habitats. Population increase and ensuing rapid agricultural and urban development resulted in an augmented demand for water, causing a severe decline in water sources for stream-flow. Today, two thirds of the population, a large majority of the industries, and a considerable share of intensive agricultural activities are located in the Coastal Plain. This demophoric growth (Vallentyne, 1972) is also reflected in rapidly growing waste production, which due to improper treatment and disposal, takes a heavy toll on the environment, especially on the aquatic habitats of the coastal streams.

The outcome of this process was a gradual transformation of rivers into conduits of waste to a degree that many of the streams presently constitute a sanitary and aesthetic nuisance (Gasith, 1992).

1.2. The Yarqon River

The Yarqon is the southern most perennial river in the Coastal Plain running through the Dan Region, the most densely populated area in Israel. The last 4-km run through the city of Tel-Aviv. Over 1.5 million people live within close proximity to the Yarqon, making this river a highly desirable site for recreation. The Yarqon River, although relatively short - 27 km, drains an area of 1800 km^2 west of the national water divide, between Jerusalem and Shchem (Nablus), and has many tributaries. Approximately two thirds of the drainage basin are mountainous and include the recharge zone for a major aquifer. This aquifer feeds the springs at Rosh Ha'Ayin, the main historic water source of the Yarqon.

The river once carried 220 million m^3 of spring water annually (25,000 m^3/hr), with storm peak discharges that have reached 500 m^3/sec. This earned the Yarqon a reputation second only to the River Jordan (Avitsur, 1957).

Diversion of the main springs at Rosh-Ha'Ayin in the mid-1950 has reduced spring discharge to zero, leaving the river with no dilution capacity. For this reason, major stretches of the Yarqon are severely polluted, mainly from domestic effluents, resulting in extensive damage to plant and animal life (Gasith, 1992, Gasith *et al*.1998, Gafny *et al*., 2000).

Today, the upper 7-km of the Yarqon carries small amounts of fresh water (ca. 200 m^3/hr) discharged by order of the Water Commissioner, as part of the water allocation for the Yarqon. This stream section maintains reasonable water quality conditions that enable existence of a limited number of animal and plant species, mostly of standing-water communities (Uzan *et al*., 2002).

A central section of 16-km down stream is polluted by effluents discharged from municipal Water Treatment Plants. Part of the stream water in this section is pumped out and used for irrigation of industrial crops. If not for the release of the effluents into the river channel, major stretches of the Yarqon in this section would dry out periodically turning the river into a mostly intermittent stream (Gasith, 1992).

The last 4-km of the Yarqon, ending at the coast of the Mediterranean Sea, functions as an estuary. Water quality conditions in this reach are slightly improved because of the flushing effect of the tide.

1.3. Rehabilitation of the Yarqon – the beginning

The Ministers of Agriculture and of the Interior initiated the rehabilitation process of the Yarqon by creating the YRA in 1988. The YRA council consists of 18 members: 3 government agencies, 7 municipalities and 8 additional public organizations. The Chairman of the Council is the Mayor of Tel-Aviv-Jaffa and the Chairman of the Board is the representative of The Ministry of the Environment, both appointed by the Minister of the Environment. The YRA's statutory boundary is confined to the 27-km of the river channel and to 20 meters on both sides of the riverbanks. The duties of the YRA include rehabilitation of the Yarqon and improving conditions for recreational activities.

Before the establishment of the YRA, there was no effective coordination between the municipalities bordering the Yarqon or between the various government agencies, and no significant action had been taken to improve the condition of the Yarqon or to deal with any of its problems or potentials. These organizational difficulties even prevented the Ministry of Agriculture from creating a Drainage Authority.

The YRA's main activities involve initiating planning processes and involvement in regional and infrastructure plans and their implementation for all projects that may influence the river and its tributaries. These activities are in the following main categories:

a. Drainage and flood control, including flow modelling and flood plain management within urban settings while insuring that the agricultural areas will remain as flood plains in order to diminish the flood flows to the urban areas.
b. Environmental and ecological aspects related to the rehabilitation of the Yarqon, including water allocation – quality and quantity, biological issues, water reuse projects and pollution prevention.

c. Recreational issues including parks and boating.
d. Routine maintenance of the riverbed and its corridor.

2. PLANNING ASPECTS

2.1. Preparation of the Master Plan

Preparing the Master Plan for the rehabilitation of the Yarqon River, one of the initial and most important actions taken by the YRA, was based on the legal framework for the protection of water sources in Israel (Gasith and Pargament, 1998).

The YRA's Board of Directors formulated the terms of reference (TOR) for preparing the Master Plan, thus creating a wide base of agreement among the members at the initial stage. Preparation of the plan required a holistic overview of the river system and integration of its rehabilitation needs.

The first task was to define the geographic boundaries of the plan and the functional properties that needed special consideration. These were:

a. The drainage basin - with respect to hydrology and pollution sources.
b. The existing open spaces around the riverbed – with respect to land use and ecological roles.

The TOR was very explicit in defining the relationship between the planning team and the steering committee. The planning team was instructed to consult the members of the Board of Directors, who were part of the steering committee, at specific stages during the planning process. This arrangement served to familiarize the Board of Directors with the hydrology and structural properties of the river and its environment and with the river's hydraulic and ecological needs, as well as to maximize their involvement in the planning process.

The goals of the Master Plan (Rachamimoff, 1996) are:

a. To create and secure a "green lung" for the most populated region in Israel.
b. To change the current public attitude toward the Yarqon from a "back yard" to an urban "front yard".
c. To rehabilitate the river's ecosystem and improve the water quality by solving the problems created by the discharge of sewage and low quality effluent.
d. To provide appropriate solutions for river regulation and flood hazard reduction.
e. To suggest economic initiatives for river uses compatible with the principles of sustainable development.
f. To improve the environmental and aesthetic values of the river and its adjacent corridor.

The preparation of the Master Plan served as a workshop for educating decision makers including mayors, city engineers and other local and government officials, of the river's structure and needs. Moreover, the plan facilitated decision making for the actions needed to initiate the rehabilitation.

After approval by the Board of Directors and the Council of the YRA, the Plan was submitted to, and approved by the Ministerial Committee for the Environment. This approval received the status of a Government Cabinet Directive in April 1996.

The Master Plan, presently being implemented, serves as a guideline for the YRA's activities. One important outcome is a Governmental Directive for the rehabilitation of the Yarqon. Accordingly, as of January 2003, a list of the actions is expected to be taken. These actions will be funded by a budget of ca. $19 million, 60% of the funds will be contributed by the 7 municipalities and 40% from government agencies.

2.2. The planning and building law

Implementation of the Master Plan with regard to land use issues is a major component of the rehabilitation process, one that will influence the river for generations to come. The statutory tool provided by the Planning and Building Law for implementing such plans is the Outline Scheme.

Planning Committees prepare Outline Schemes, which reflect the policy of the Ministry of the Interior with regard to zoning and land use planning strategies for the entire country.

The Yarqon area is divided between two such Regional Planning Committees and therefore two separate Outline Schemes had to be submitted.

The Outline Schemes delineate an area of approximately 9880 acres (ca. 4000 hectares) which will be zoned according to the goals of the Master Plan. An important element in the Outline Schemes is the delineation and protection of the flood plains, as part of the overall flood control plan in built-up areas. The Outline Schemes impose constraints on building and development in general, defining minimum elevation for any built structure approved within the flood plain. In addition, the YRA participated in the inclusion of runoff guidelines, developed by Planning Commissions, with regard to urban plans. This implies that new building plans must include elements of runoff control such as use of grassed waterways and diversion of local runoff to small retention ponds in order to reduce runoff and increase infiltration and water harvesting.

3. WATER RELATED ISSUES: QUANTITY AND QUALITY

The competition for water in Mediterranean-climate regions is often compounded by water pollution, which threatens the existing supply of water and exacerbates the damage to river ecosystems. Israel, one of the most water stressed countries (World Resources Institute, 1996) has extensive water reclamation and reuse projects. Implementation of the Master Plan with regard to the quantity and quality of the water needed for the rehabilitation of the Yarqon is a very complex task. It requires coordination with at least six different government agencies, several NGOs and private sectors with water rights and interests.

3.1. Water quantity

Ecological considerations of stream rehabilitation call for the allocation of at least 10% of the original natural base flow, i.e. 2500 m^3/hour. However, in drought years this becomes a difficult task to fulfil because of a nation-wide decline in water supply. Consequently, in the rainy period the river will function as a natural system, whereas during the dry season it will require allocation of water. Following analysis of the possibilities, it was decided that three principles will be applied in order to ensure allocation of water for the Yarqon in summer. These principles are based on the Master Plan and are imbedded in the 2003 Governmental Directive:

a. The upper relatively undisturbed 7 km section, will receive source water at a rate of 200 m^3/hr discharged from wells in the aquifer that used feed the springs in the past. The allocation will increase to 400 m^3/hr, once the national water balance is improved due to additional water from desalinization plants. In addition, 1000 m^3/hour will be circulated in order to increase the velocity of flow in this section. The circulation of fresh water will be monitored for possible accumulation of organic matter, nutrients and dissolved salts. The flushing that occurs during the winter and the addition of water to compensate for losses are expected to be sufficient to prevent the accumulation of pollutants and maintain the river's integrity and health.
b. The middle section, 16 km long, will receive high quality effluents (see 3.2) at a discharge rate of 2500 m^3/hour. The quality of the effluents will meet the requirements for sustaining aquatic life, including plants and fish that thrive in the upper unpolluted section of the Yarqon. At a downstream site most of the water will be diverted out of the stream for reuse in irrigation projects.
c. The perennial nature of lowest, (estuary) section will be maintained by allocation of water as needed.

Application of these principles, together with the winter floods, will reinstate a Mediterranean type flow regime (*sensu* Gasith and Resh, 1999).

3.2. Water quality

The quality of the water in the Yarqon is governed by three main factors: the source of the water; the rate of exchange (retention time) and sediment quality. The need to circulate fresh water in the upper most section of the Yarqon may lead to deterioration of its quality due to possible accumulation of organic matter, dissolved salts and other pollutants. In that case, additional measures (e.g. treatment of the circulated water, e.g., "stream dialysis", Gasith, unpublished) will be needed to avoid progressive degradation of the water quality.

According to the Master Plan the quality of the effluents permitted for discharge into the middle section of the Yarqon is as follows (maximum values, except for dissolved oxygen): Biological Oxygen Demand – 10 mg/l; Suspended Solids – 10 mg/l; Dissolved Oxygen – 4 mg/l (minimum); NH_4 (Ammonia) – 3 mg/l; Fecal Coliforms – 100/100ml.

These criteria are part of new regulations recommended by an ad-hoc committee.

The main sources of effluents that are discharged into the Yarqon are two waste water treatment plants (WWTP). The larger of the two, designed to serve a population of approximately 150,000, started to operate in 1997. While the quality of the effluent has improved greatly since the commencement of the operation, it does not meet the effluent quality requirements. The Government Directive includes upgrading this WWTP to the required effluent quality. The second treatment plant is designed to serve a population of 45,000 and started its operation in 1999. The quality of the effluent from this plant complies with the requirements for discharge into the Yarqon, excluding phosphorous concentrations.

3.3. Pollution prevention

The following pollution prevention measures are planned:

a. Dry weather pumping stations at the outfalls of municipal drainage systems for preventing accidental sewage flows due to faulty operation.
b. Constructed wetlands for effluent upgrading, and levelling out fluctuations in the effluent quality.

Additional pollution sources that require consideration originate in areas under the jurisdiction of the Palestinian Authority. The YRA is in close contact with the Ministry of the Environment and the Water Commissioner's office, requesting assistance in solving cross-boundary pollution problems.

The issue of sediment quality is yet to be resolved. So far this problem has been addressed in a sediment survey along the Yarqon (Avnimelech, 1999). Several reaches have been identified as sludge sinks; however, it is not clear when sediment accumulation occurs. Initial results indicate that most of the accumulation of organic matter occurs in the summer as a result of algal blooms and die off, as well as sedimentation of organic matter of wastewater origin. Winter floods add particulate matter, oils and grease mostly from urban areas (Avnimelech, 1999). The survey will continue in order to study the effects of winter floods on sediment and sludge transport and flushing. When the required water quality will be reached, the survey will address the question of organic matter accumulation under the new conditions.

4. HABITAT RESTORATION

One of the major undertakings of stream rehabilitation is the reconstruction of riffle and pool habitats. Improved flow regime combined with the restoration of in-stream habitats will enhance self-purification processes and recolonisation of plants and animals. Several investigations were conducted to assess the biotic response of macroinvertebrates and fish to the different water quality and habitat conditions in the river (Gasith, 2000; Goren, *et al*., 2000).

The vegetated banks and adjacent areas form the riparian zone. This zone provides habitats for bank communities and functions as a source of natural organic matter, as a buffer zone from human activity and as a natural means of bank stabilization. Reinstating the structural and functional values of this zone, as well as its aesthetic values, are important tasks of the rehabilitation plan. Stabilizing

the river's banks using environmental friendly structures, eliminating competitors (e.g. eucalyptus that was introduced from Australia) and planting native trees (e.g. willows) are expected to enhance growth and establishment of natural riparian vegetation.

Certain habitat restoration actions have already been taken. These include construction of riffles and pools and planting of riparian vegetation. Private land ownership proved to be major obstacle of restoration of the riparian zone. In some instances the YRA receives good cooperation from landowners in the vicinity or within the stream corridor however, many landowners are suspicious of actions taken by the YRA to rehabilitate the river. The YRA is making a major effort to convince the landowners of their benefits in the rehabilitation program. One example involves farmers who have water rights to pump water out of the river for irrigation of crops and orchards. Small waterfalls constructed by the YRA in order to restore riffle habitats and maintain channel wetness during the dry period also facilitated water pumping by restoring stream depth.

The river riparian corridor is the site assigned for recreational activities along side the stream channel. Funding and cooperation of landowners are the main limiting factors of corridor rehabilitation.

5. RIVER REGULATION AND FLOOD HAZARD REDUCTION

Prior to the establishment of the YRA many buildings and infrastructure elements were erected within the flood plain, limiting the ability to implement measures to reduce flood hazards. The YRA funded an extensive study of the Yarqon's hydrology in order to establish an integrated concept for the protection of urban areas and reduction of flood hazards to large parks and agricultural areas.

The concept that was developed by the YRA incorporates improving the Yarqon's hydraulic capacity together with defining and protecting remaining flood plain areas. Improving the hydraulic capacity is part of a comprehensive statutory plan, prepared and submitted by the YRA that has been approved by the Minister of Agriculture, based on the 1957 Drainage Law. Defining and protecting the flood plains will be facilitated through the Outline Schemes and regulations regarding runoff control. Government agencies and local authorities involved in developing and implementing the new regulations are aware of the difficulties but also of the necessity to act in order to decrease future potential damage.

The Yarqon's watershed has an area of approximately 1800 km^2 (180000 hectares). The Ayalon tributary, which enters the lowest (estuary) section of the Yarqon, drains about one half of the watershed area. Flood protection is based on improvement of the hydraulic capacity of the Ayalon channel in urban sections and protecting of existing floodplains areas. Two target discharges, calculated to 1.5% probability, were chosen by the YRA: A maximum discharge of 600 and of 800m^3/sec in the Yarqon channel is planned before and after its confluence with the Ayalon tributary, respectively.

5.1. Hydraulic capacity

Measurements have shown that before its confluence with the Ayalon, the Yarqon can convey approximately 250 m^3/sec without flooding built-up areas or parks adjacent to the river. The regulation plan includes improving the hydraulic capacity of the river to 400 m^3/sec. Discharges exceeding this will flood parks, but not built-up areas.

Downstream the confluence of the Yarqon and the Ayalon, the present river's hydraulic capacity is approximately 500 m^3/sec and can not be increased because of existing man-made structures.

Implementation of the plan for increasing the hydraulic capacity is further complicated by the fact that the Yarqon channel acts as a border between different municipalities. Questions involving the kind of actions needed where and by whom they will be executed are "political" rather than professional and require many meetings and debates as well as a lot of manoeuvring between the different parties.

5.2. Flood plains and runoff control

In the urban reaches, existing buildings dictate the boundary of the flood plain. Thus, in order to achieve the required protection it is necessary to install levees and retention walls. The YRA adopted the method proposed by FEMA (USA Federal Emergency Management Agency, USA), relating to future hydrological conditions for defining floodways and floodway fringes in urban areas where there are conflicts between economic and hydrologic interests. Engineers, architects and ecologists will cooperatively design the structures in order to ensure the river's needs. This will be done by combining land use and environmental aspects.

6. RECREATION

The Yarqon Master Plan recommends preparing areas for recreation along the river corridor. While the YRA does not replace the municipality in urban and planning issues, it was clear that dealing with the river's needs, in combination with urban recreational planning needs, creates an opportunity. To facilitate this, the YRA has prepared an extensive plan promoting recreational use along the river, for example, by developing bicycle and jogging paths. Parts of this plan are now under construction.

7. CONCLUSION

The rehabilitation of the Yarqon is the first major effort of stream rehabilitation in Israel. It could not have begun without creating the appropriate organizational framework i.e. a river authority. The YRA has been operating for 14 years during which a major part of its activities was the planning and initiation of a rehabilitation program. This required consideration and integration of multi-varied planning facets and the support of decision-makers and politicians from all levels of government. Implementation of the Yarqon's Plan depends among others on such support and on allocation of the necessary funding.

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