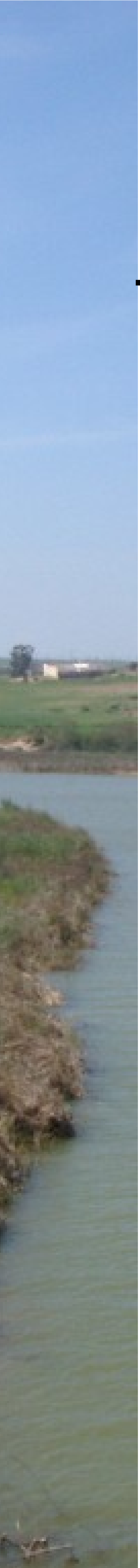

Assessment and Provision of Environmental Flows in Mediterranean Watercourses

- Basic Concepts, Methodologies and Emerging Practice

Mediterranean Case Study

Assessing groundwater and surface water flows through Aammiq Wetland

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The views expressed are those of the authors and do not necessarily reflect those of IUCN.

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1. Basin and policy context

1.1 Background

Aammiq wetland, Ramsar site 978, is one of only three or four wetlands remaining in Lebanon, and is generally considered the healthiest and most significant among them. The wetland (33° 44’ N, 35° 47’ E) is situated in the Bekaa plain, a broad, fertile plain that stretches between the Lebanon and Anti-Lebanon mountain ranges at an altitude of 850-1000 m a.s.l. The wetland lies on the western side of the plain, at the foot of the Lebanon Range (here called the Barouk Ridge) from where it receives its water supply. Total precipitation in the area is moderately high, averaging between 700-880 mm per year on the plain, and up to 1500-1600 mm per year on the Barouk slopes (Plassard, 1972; Chapond, 1976). However, precipitation is extremely seasonal, occurring almost exclusively in a period of 80-90 days between November and April; from June to August, rainfall is extremely rare (Sene et al., 1999). This highly seasonal pattern is responsible for the major water stresses in the region. Soils on the Barouk slopes are thin, and rain and snow-melt penetrate rapidly into the fissured limestone, which forms the main aquifer in the region. At the foot of the mountain, beneath the plain, the main groundwater flow direction is north to south. Here, the groundwater is confined by the thick clayey sediments of the valley floor, but in the region of the marsh, probably due to outcropping of the limestone, the groundwater emerges as springs at the foot of the mountain. From the springs, the water flows over the land surface 3 km eastwards to the Litani River in the middle of the plain, spreading out over an area of about 280 hectares.

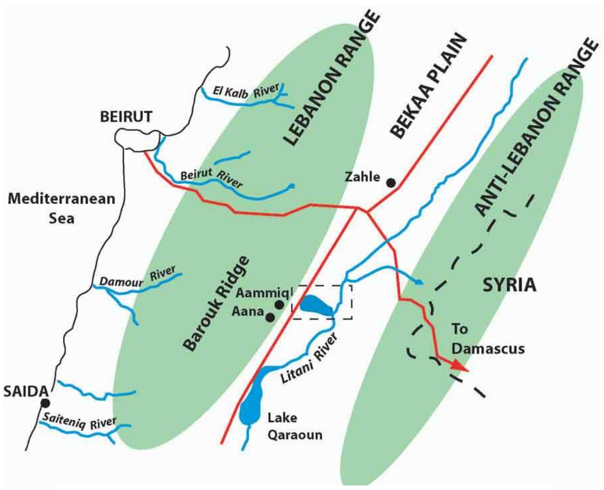

Fig. 1a Location of Aammiq Wetland.

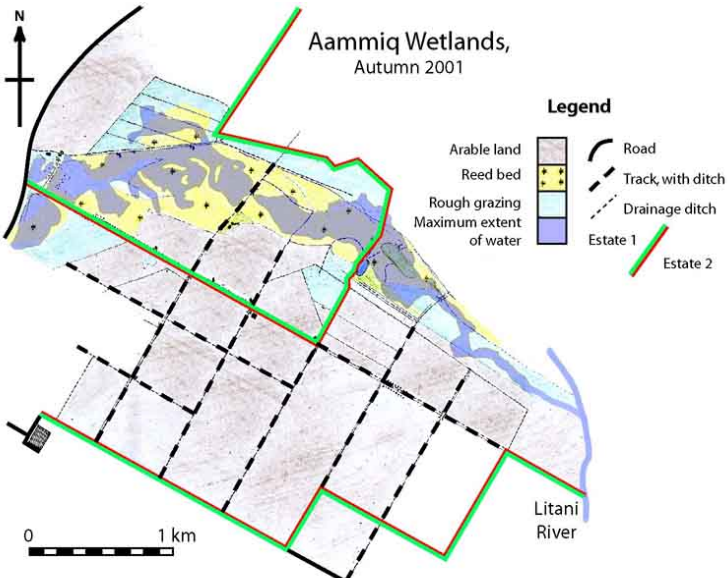

Fig. 1b Boundaries of Aammiq Wetland.

1.2 Ownership

The entire Aammiq region is in private ownership. About 70% of Aammiq marsh itself is owned collectively by four members of one family, who also own a large area of agricultural land surrounding the marsh. Their estate is referred to here as Estate 1. The remaining 30% of the marsh (plus large areas of surrounding agricultural land) is owned collectively by 52 members of four other families. Their estate is referred to here as Estate 2. See Map 1 for boundaries of ownership. The agricultural lands of these families are rented on a year-by-year basis to tenant farmers for grazing of sheep and goats, and production of wheat, corn, alfalfa and vegetables. On Estate 1, the marsh is surrounded in most places by a "buffer zone," on which there is no planting of crops, and limited grazing.

1.3 Flow alterations and water stresses

Fig. 2 Looking west across Aammiq Marsh.

Historically the wetland used to cover a large proportion of the Bekaa plain, reaching northwards up to thirty kilometres from its current extent. However, because of the high fertility of the Bekaa soils, parts of the plain have been converted to farmland since ancient times. The last major effort to drain the wetland for agriculture occurred during the 1960s and early 1970s, with the digging of an extensive network of drainage ditches across the plain, and building of levees around the Litani River to prevent river water spilling onto the plain during floods. These efforts reduced the wetland to approximately its current size. Ditches were also dug in Aammiq marsh itself, accelerating desiccation during the dry season, but these have since been closed in the interests of conservation. Conflict between the interests of local farmers and the interests of wetland flora and fauna are still the main root cause of water stresses in the marsh.

Water stresses in the Bekaa are opposite between winter and summer, due to the highly seasonal pattern of precipitation. In winter and spring, excess water presents a stress to local farmers, as large rainfalls flood the plain and threaten to drown winter crops. Drainage ditches are used to remove flood waters as quickly as possible from fields, but unusually high rainfalls may still cause damage to crops. During the summer, high temperatures (averaging 32-34° C; UNDP/FAO), strong winds and a total absence of rain produce a severe water deficit. Irrigation needs are thus very high, and surface waters in the region are insufficient as a water source. Therefore, in the last 40 years, more than 30 water wells have been dug along the foot of the Barouk mountains north of the marsh, to pump water from the limestone aquifer that provides water to Aammiq marsh. Although many of these wells are currently not in use, groundwater extraction is thought to be an important reason why the marsh, which used to remain flooded throughout the year, now reduces to a few small pools for 5-6 months of an average year. A large pump that extracts water directly from the marsh halfway along its course exacerbates this seasonal drying. However, not all human alterations to the natural flow regime reduce water levels in the marsh. Because marsh water is extracted for irrigation and watering of sheep, local farmers dam the natural marsh outflow during the summer months to retain water in the marsh for as long as possible. This significantly slows the rate of drying.

Also competing for water in the area are the local villages. Three villages (Aana, Deir Tahnish and Aammiq) extract water for domestic supply from three springs higher on the Barouk slopes. According to Walley (1997), these springs used to provide about 20% of the water supply to Aammiq marsh, but presently little, if any, water from these springs reaches the marsh.

Therefore, patterns of water flow in the Aammiq region have been highly modified for the benefit of local residents and farmers. To date, only minor adjustments have been made to benefit conservation values in the Aammiq wetland.

1.4 Policy context

At present Lebanon has no laws governing minimum flow requirements in any water courses. A major review of environmental law is expected to begin before the end of 2003, but it is not known whether minimum flow requirements will be introduced following this review. Furthermore, water abstraction for irrigation in the Bekaa is effectively unregulated, meaning that at present, individuals may withdraw any amount they wish. Because of this lack of legislation, any changes in water management that are recommended on the basis of this environmental flows assessment would be implemented voluntarily by the various landowners. The role of A Rocha Lebanon, author of the environmental flows assessment, is purely advisory.

2. Background to the environmental flows assessment

2.1 Motivation and aims

Action to assess the water resources of Aammiq marsh has been motivated by growing recognition of its international importance. Although official recognition dates back to 1980, with inclusion of Aammiq in the directory of wetlands of the Western Palaearctic as a "wetland of international importance" (Carp, 1980), the current momentum for conservation is largely due to data on the extremely high diversity of birds, gathered since 1997 by A Rocha Lebanon. A Rocha Lebanon is a non-government organisation, part of A Rocha International, which has a mandate to conserve significant habitats in areas that lack resources for conservation. Since 1997, A Rocha Lebanon has been working at Aammiq in an advisory role with the land-owning family of Estate 1. As well as accumulating data on the biodiversity at Aammiq, A Rocha Lebanon has actively advocated for conservation of the marsh among the owners of Estate 1, leading to a commitment within that family to protect the parts of the marsh that exist on their land.

In its Management Plan for Aammiq (2002), A Rocha identified an aim "to maintain, and where possible, enhance the size, functionality and biodiversity of the wetland ecosystem." As A Rocha and the Estate 1 family recognised that reaching this aim required a better understanding of the hydrological requirements of the marsh, both parties saw a need for a quantitative study of the marsh hydrology, and monitoring of water quality.

In particular, key questions were:

- Can we increase water supply to the marsh without conflicting with agricultural needs?
- How much water must be added to the marsh, in order to significantly increase the area of the marsh or the length of time it stays flooded?
- If water is added, which new areas will flood first?
- Is groundwater pumping on adjacent lands removing water from the marsh?
- Is it feasible to create permanent water within the marsh area, and would this have positive or negative effects on biodiversity?
- Is water quality in the marsh of sufficiently high quality to maintain natural functions and values?

In order to answer these questions, we first needed answers to some fundamental questions about the marsh hydrology:

- how much water enters the marsh from different sources?
- how much water is lost from the marsh through different pathways?
- what are the physical properties of the marsh and the surrounding lands that determine the way that water enters and leaves the marsh area?

The scope of the study, however, was limited by a number of factors. The first was personnel; only one member of the small A Rocha team had sufficient experience and knowledge of hydrology to conduct the study. Second, the lack of background data meant that very little could be discovered regarding the behaviour of groundwater. The extent of the mountain catchment could not be determined due to the complex folding and faulting of the fissured limestone beneath the mountain; gains and losses of water vertically through the marsh sediments could not be assessed because the geology of the valley sediments is complex and not well known; and regional groundwater flow directions could not be precisely determined because logs of groundwater levels or aquifer properties do not exist for the many water wells in the region. Third, constant and unpredictable alterations to the marsh inflows and outflows made quantifying surface water flows difficult. On this nearly horizontal plain, water can be made to flow in almost any direction, and a number of ditches that intercept the marsh are frequently opened, closed and redirected to move water between the marsh and the nearby agricultural fields.

Because of these limitations, it was decided to limit the study initially to:

1. determining the extent of the flooded area at different water levels
2. quantifying as many as possible of the inflows to and outflows from the marsh during one hydrological year.
3. gathering any available evidence that groundwater pumping in the vicinity affects water supply to the marsh.
4. determining the hydraulic conductivity (permeability to water) of the near-surface marsh sediments.
5. noting the actual usage of water for agriculture in the vicinity of the marsh, and identifying any potential changes in water management that would increase water supply to the marsh.
6. collecting samples for water quality analysis from key points in the marsh at 6-week intervals during one hydrological year.
7. comparing the diversity of aquatic invertebrates from temporarily vs. permanently flooded habitats.

2.2 Stakeholder involvement

The major stakeholder, the family owning Estate 1, has interests in continuing agricultural production on its estate, in developing the ecotourism potential of the marsh and surrounding region, and in conservation for its own sake. The owners of Estate 2, to this point, have expressed interest only in agricultural production. The tenant farmers on both estates have agricultural production as their primary concern, but as the residents closest to the marsh area, they also often express personal appreciation for, and desire to protect, the natural values of the marsh. Other stakeholders include the nearby village of Aammiq, which has potential to benefit from the arrival of ecotourists, and MedWet Coast (associated with the Lebanese Ministry of Environment/UNDP), who have recently become involved in the management of Aammiq marsh with a mandate for conservation and ecotourism.

Despite the number of stakeholders with interests in the natural values of the marsh, agricultural interests presently dominate water management at Aammiq and in the wider region. A Rocha Lebanon is undertaking the environmental flows assessment within its role as provider of scientific data and scientifically-based advice for the conservation of Aammiq marsh. Therefore, although the study is being conducted with a recognition of agricultural interests, its primary aim is to ensure that water supply to the marsh remains of sufficient quality and quantity to sustain natural values.

3. Conducting the environmental flows assessment

3.1 Methods

Just as the aims of the environmental flows assessment were designed to fit within the limitations of personnel, lack of baseline data and unpredictable water management, so the methods employed were chosen to be rapid, low-technology and flexible.

First, staff gauges were installed in the marsh to record water levels. For each 10 cm rise or fall in water level, the extent of the flooded area was mapped by tracing the marsh boundary using a GPS. This gave a series of contour maps that could be used to calculate the total volume of water in the marsh. Also, a map of the wetted area during a 1-in-50 year flood event showed which lands around the marsh would be the first to flood if we were able to increase the water supply to the marsh in the future.

A nearly-complete water budget for the marsh was compiled by recording as many inflows and outflows as possible and relating these to annual precipitation. To measure inflow flux from the springs at the western end of the marsh, two rectangular weirs were constructed where the springs flow into the marsh itself. Inflows from the fields to the south of the marsh were measured using a V-notch weir, located in a ditch that collects water from all the ditches to the south. The outflow of the marsh was identified and outflow flux was measured using a hand-held impeller-type current meter and the cross-sectional area of the outflow point. By comparing the outflow flux to the flux of the various measured inflows, we could calculate the flux of other inflows, such as groundwater upwellings within the marsh area, that could not be measured directly with the available equipment. Precipitation data were collected from a local weather station. The water budget lacked data on vertical water losses to groundwater. However these could be estimated by recording the rate of decline in the water level of the marsh, in relation to its volume, during the dry season, when the surface outflow of the marsh is blocked.

The effect on the marsh of groundwater pumping from nearby water wells was demonstrated by recording daily fluctuations in the water level of the springs, in relation to the hours that the pumps were switched on and off. By recording the timing and magnitude of fluctuations on different days when different pumps were in use, it was possible to demonstrate which pumps affect the marsh most, and from this to infer the main direction of groundwater flow in the Aammiq region. These findings will be confirmed in the next few months by injections of a dye tracer into the groundwater. However, although it was possible to show the relative influence of different pumps, it was not possible to quantify the amount of water withdrawn from the marsh by each pump.

Hydraulic conductivity of the marsh sediments will be determined by “slug tests.” These involve installing piezometers, or mini-wells, up to 4m deep in the marsh sediments and recording the rate that the water level inside the piezometer recovers after the level is artificially raised or lowered.

Water quality was monitored simply by taking water samples from the springs, from a ditch that brings water from the adjacent fields, and from two other points at intervals along the length of the marsh. Using these points we were able to assess the quality of the main groundwater supply and farmland runoff, as well as the capacity of the marsh to remove excess nutrients. Water samples were sent to a nearby lab for analysis. Analysis was limited to major nutrients and basic chemical properties such as pH and total dissolved solids. Pesticides and herbicides could not be measured within the project budget, but it is hoped that they can be included at least once in future tests.

The various measurements were able to be performed by a single person, spending on average 2-3 days per week, using basic equipment. Thus they were appropriate for the resources available.

3.2 Major constraints and limitations

One of the major constraints in the study was the lack of data on the geology and aquifer properties of the region, and the lack of records of pumping rates. Had the subsurface geology of the Bekaa plain been known, particularly beneath the marsh, and had pumping test data for the nearby water wells been available, it may have been possible to model the marsh hydrology using a computer-based model. This would have led to a more accurate estimate of the marsh water budget, and allowed different scenarios of water management to be tested. With additional data on the rates and hours of pumping from the various water wells, it may have been possible to quantify the individual effects of different pumps on the marsh water supply, using the same model.

The methods actually used suffered from two main limitations. First, the constant opening and closing of ditches that connect with the marsh near its outflow affected the accuracy of the flux measurements, introducing some error into the water budget estimates. These errors were handled simply by describing confidence limits for the data. Second, the fact that pumping from water wells near the springs is unscheduled meant that investigations into the effect of individual pumps on the springs were not as focused as they could have been, and some conclusive data may have been missed.

Some uncertainty also surrounds the water quality data. Since samples were delivered to an outside lab, the care taken with analysis and sample handling after delivery could not be guaranteed. On one occasion, duplicate samples were sent to a second lab, where results differed somewhat, though they were in the same broad range. Accurate assessment of water quality will require sending further samples to a university laboratory.

4. Key measures to improve environmental flows

4.1 Recommendations and expected benefits

At the time the environmental flows assessment was begun, there appeared little scope for changing the water management around Aammiq marsh. Therefore the flows assessment was carried out mainly to gather baseline data on the current state of the marsh hydrology, to determine some of the key hydrological properties of the marsh and to set up a protocol for ongoing monitoring. Nevertheless, some possibilities for improving water management did emerge from the study.

Results to date show that the groundwater pumps north of the marsh affect the water supply to the marsh springs more than those to the south, even though they are further away. Therefore it appears that the most feasible way to increase environmental flows to Aammiq marsh is to reduce groundwater pumping to the north. The fields immediately north of the marsh belong to Estate 1. Therefore, our recommendation to the owners of this estate is either to rearrange the various crops on their estate so that less thirsty crops, such as wheat, are sited on these fields, or to introduce more efficient irrigation techniques, such as drip irrigation, on these fields. Ideally both measures would be implemented. The environmental flows assessment, and observations by local people, suggest that groundwater pumping north of the Estate 1 also reduces water supply to the marsh. To confirm the behaviour of groundwater between this area and the marsh, A Rocha is beginning a new, broader programme of groundwater and surface water monitoring. The pumps north of Estate 1 belong to a variety of different land owners, and at present, A Rocha Lebanon has no close relationship with any of these. Therefore, if further monitoring confirms the that the marsh water supply originates from this area, A Rocha will propose, in co-operation with the Society for the Protection of Nature in Lebanon and MedWet Coast, a new project to assess agricultural practices on lands up to 10 km north of the marsh. The aim is to minimise consumption of water and use of harmful agricultural chemicals. Because lands north of Estate 1 do not border the marsh, the landowners may not feel a strong connection to it, and therefore we expect it will be difficult to implement any changes to pumping regimes in this area. However, by involving agriculturalists in the project, we hope to find solutions that minimise the cost to farmers and make the proposed changes as attractive as possible.

According to current data, reducing groundwater pumping on Estate 1 north of the marsh would likely cause a significant increase in the water level and flooded area of the marsh during spring and early summer, and extend the flood period to later in the year. However the size of this effect cannot yet be predicted. If groundwater pumping further north could also be reduced, it is possible that the springs flow to the marsh might become permanent again.

Another recommendation to increase water levels in the marsh during the dry season is to repair an old sluice gate halfway along the length of the marsh, within the boundaries of the Estate 1. Although providing no benefit for the "lower marsh" to the east, this sluice gate would benefit the "upper marsh" by isolating it from the large pump that still withdraws water directly from the marsh east of the gate. Water in the upper marsh would still be lost gradually to the groundwater, and possibly to the lower marsh via subsurface flow, during the dry season; therefore this measure is unlikely to lead to permanent water in the upper marsh. However, it would certainly slow the decline of water levels during the dry season, extending the flood period.

More beneficial to the marsh would be to close the pump connected directly to the marsh, and create a new sluice gate at the lower end of the marsh within Estate 2. This would maintain higher water levels throughout the entire marsh area, but would require the land owners agreeing to manage water levels for conservation purposes and finding a new source of water for their vegetable fields near the eastern end of the marsh.

The benefits of increasing marsh water levels and extending the flood period for the marsh flora and fauna are not yet known. Observations from a particularly wet year in 2003 suggest that some species of water fowl would remain throughout the summer, and raise young in the marsh. Other birds migrating south during the autumn would likely benefit from the habitat and food source provided by the open water, as they do in spring. The effects on invertebrate life are not as easily predicted, since temporary water bodies can have higher diversity of aquatic invertebrates than permanent waters. The surveys of invertebrate communities from temporary and permanent water bodies in the area are expected to help determine whether diversity would rise or fall if permanent water were re-introduced in the marsh. The effects on fish, frogs and mammals have not been studied but would almost certainly be beneficial.

Another likely benefit of increasing the marsh water levels is a reduction in uncontrolled fires within the reedbed. In the last several years, accidental and irresponsibly lit fires have destroyed large sections of the marsh reedbeds during the dry season, and ignited the peat soils, which then remain smouldering for several months until the water table rises again in winter. Although fire can be used as an effective management tool to reduce the build-up of excess organic matter, uncontrolled fires destroy very large sections of the reed habitat, which certain plant and animal species may not be able to tolerate. Also, the resulting peat fires are a nuisance to local residents and lead to negative attitudes towards the wetland. Protecting the reedbeds from uncontrolled fires is difficult, thus reducing the risk of fires by increasing water levels would be of great benefit.

4.2 Implementation of changes

Since all of the marsh and surrounding lands are privately owned, changes to water management depend entirely on the owners of the two main estates, and their estate managers. Data collection for the environmental flows assessment has not yet been completed, therefore none of the above recommendations have yet been made. However, informal discussions with a key member of the Estate 1 family have met with a positive response. The main obstacle both to repairing the sluice gate within their estate, and to introducing drip irrigation in the northern fields is likely to be cost. The land owner has asked A Rocha to list a range of options for water management, with environmental benefits and financial costs to be quantified for each, so that an optimal solution can be found.

In the past, the owners of Estate 2 have been unwilling to implement any changes that might place extra restrictions on, or cause extra expense to, agricultural production. Therefore it is unlikely at this time that they would be willing to stop pumping from the marsh, construct a sluice gate for conservation purposes, or reduce groundwater pumping from their boreholes. However, we hope that as A Rocha and MedWet Coast continue to advocate for the marsh, and present alternatives, such as ecotourism, for diversifying income generation on the estate, there will be some change in attitude.

Because the laws in Lebanon regulating abstraction of water for agricultural use are weak and usually not enforced, any changes to water management would have to be done on a voluntary basis. This means that land owners either must see a potential benefit in reducing their water usage, or must interested in contributing to conservation of the Aammiq marsh. Until the results of this study, the potential impact of farmers north of the Estate 1 on the marsh were not known, therefore no attempt has yet been made to discuss water management with them. However such discussions are unlikely to result in management changes unless benefits to those landowners can be demonstrated.

It is worth noting here that maintaining optimal water balance for agriculture can require considerable effort and cost by land owners. In the past, the owners of Estate 1 have allowed certain marginal lands to revert to marshland because the effort and cost of draining them was too high. Some other lands surrounding the marsh on Estates 1 and 2 also are marginal for farming for the same reasons, and in the future might be returned to the marsh for purely practical reasons.

4.3 Ongoing research and monitoring

A central aim of this environmental flows assessment was to lay a foundation for a wider programme of groundwater and surface water monitoring. Fluxes of water entering and leaving the marsh through the springs and ditches will be monitored by weirs installed at key inflow points. In the event that water demands in the area increase in the future, this programme will provide early warning that environmental flows to the marsh are decreasing. In the event that positive changes to water management in the area are implemented, this programme will provide feedback as to the effects of these changes.

Groundwater levels and levels of surface water in isolated pools around the Aammiq region also will be monitored, through a network of piezometers, gauging boards and a few open wells. These will give a better understanding of the degree to which the marsh is connected with the shallow water table in the surrounding agricultural lands, thus indicating how sensitive the marsh is to agricultural practices that raise or lower the regional water table. In addition, a weather station is being installed at Aammiq to monitor rainfall. Therefore, a single operator with some knowledge of hydrology and an ability to cope with alterations to the drainage pattern or extreme rainfall events should be able to continue gathering all the data required for an annual marsh water budget.

Ongoing monitoring of bird numbers and behaviour also will continue, giving feedback as to some of the ecological effects of any changes in marsh hydrology.

5. Lessons to draw from this study

5.1 Essential elements

Since no changes to water management have yet been implemented on the basis of this study, it is too early to gauge its ultimate impact, and therefore to say what contributed most to its success. However, there are several elements that have enabled the study to proceed this far, and that suggest the final recommendations will be well received.

The most important element enabling this study to begin was a close, positive relationship with the main land-owning family. This relationship, which dates back to 1997 when A Rocha began work at Aammiq, has been built, on one hand, through many hours discussing the values and benefits of conservation with the landowners, and on the other, through a willingness by A Rocha to combine its aims with those of the landowners. It is probably also significant that the entire A Rocha team reside locally, are immersed in the local culture, and interact almost daily with employees of the estate. These elements provide stability in the relationship and opportunities to grow in mutual respect. Out of the mutual trust that has developed, several scientific studies on birds, butterflies and mammals have been conducted on the estate, and protocols have been established for such studies. Water, being a scarce resource in the region, is a much more sensitive issue than the subjects of previous studies, the implications of a hydrological study for changes in estate management being potentially more far-reaching. Therefore this hydrological assessment has relied on the successful protocols established by those studies, and their positive outcomes. Transparency in discussing methods and reporting results has been very important in cementing trust between A Rocha and the main land-owning family.

The environmental flows assessment was the first of A Rocha's studies to require building structures on the land of Estate 2. The risks perceived by this estate were first that the study itself would involve altering flow patterns (especially slowing drainage during the wet season), and second that encouraging the collection of such data might later result in pressure to change their land or water management. Spending time to explain clearly what the intentions and scope of the study were, and promising to remove structures if they interfered with agricultural needs, were essential in gaining permission to work on this estate.

On a practical level, a key element was the use of a flexible methodology for collecting water flow data. In a situation where water is constantly redirected to drain or irrigate surrounding fields, and where a winter's rainfall can be double the yearly average, methods had to be flexible enough to cope with new outflows, inflows and over-spills from week to week. Hence a portable current meter was much more suitable than a system of weirs for measuring outflows from the marsh, and also could be used in addition to the weirs to measure new inflows as they were created. Being able to respond rapidly to new opportunities for data collection also has greatly benefited the study. In particular, it was not anticipated that pumping of nearby groundwater would cause the water level in the marsh springs to fluctuate. However, being able to set up an intensive sampling schedule during the brief period when the effect was visible enabled the collection of some critical data. Living close to the marsh was certainly essential to being this flexible.

At the stage of recommending changes in management to the various land owners, a strength of this environmental flows assessment will be that it is based on scientific data. In the Bekaa there is much talk about water management, but typically there is little or no data available to inform decisions. We hope that this flows assessment will gain credibility among the stakeholders because of its reliance on scientific data. Further, we hope that it will become a model for other water managers in the Bekaa region.

5.2 Key constraints to address

Two major constraints on effective water management in this region have already been discussed: the lack of regional water-related data and the lack of effective legislation regulating water abstractions and minimum flows to aquatic habitats. Another major constraint is a lack of awareness and concern among the general public for protecting natural ecosystems. Since, in the current absence of effective legislation, water management for conservation values depends on voluntary co-operation by local landowners and farmers, an ethic of care for natural systems, and a basic understanding of how to achieve this, are essential. Clearly, the attitudes of the landowners themselves are most important, but the attitudes of the wider population can affect how much incentive and support the landowners feel to protect natural ecosystems. In the long term, we expect that the success in maintaining viable environmental flows and other key components of the ecosystem at Aammiq will depend on more than the landowners. Key decision-makers in government, university researchers and local residents, will likely influence the long-term survival of the marsh ecosystem.

The key to changing attitudes towards the environment is education. For this reason, A Rocha runs an active environmental education programme for students from primary school to university age, based in field activities at the marsh. A Rocha also runs environmental art and science clubs among women and children in the local villages. For many students, the Aammiq field trip is their first experience of nature study outdoors, and for most local residents, it is their first visit into the marsh. The response to the field trip and other education programmes is almost always enthusiastic. While these programmes are not directly connected to the environmental flows assessment, they are essential in improving attitudes towards nature among a number of key sections of the population. Therefore they are helping to establish a context within which studies such as the environmental flows assessment can translate into action.

Timeline of major events

Date	Event
1960s-1970s	Large areas of southern Bekaa valley drained for farmland. Ammiq wetland reduced to approx. current size. Groundwater pumping for irrigation begun
1975	Discussions begun between G. Tohme (Lebanese University) and owners of Estate 1 to preserve Aammiq marsh.
1975-90	Lebanese civil war halts all conservation efforts.
1997	A Rocha Lebanon launched, with main aim of protecting Aammiq Marsh.
1998	Major drainage ditches within the marsh area closed; marsh boundaries marked by poles.
1999	Large area on north side of marsh retired from farming, adding 20% to marsh area.
1999	Aammiq marsh declared Ramsar Site 978.
2001	Sugar beet subsidies ended. Sugar beet replaced by less thirsty crops. Many groundwater pumps closed.
2002	Aammiq becomes an official MedWet Coast project, with appointment of a full-time MedWet Coast co-ordinator. Process begun of writing laws to allow private lands (including Aammiq) to become official nature reserves in Lebanon.
2002-04	Environmental flows assessment at Aammiq, ongoing monitoring of water flows begun.

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We would also like to acknowledge comments provided on the consultation draft.

A Rocha is an international conservation organisation working to show God's love for all creation.

Websites

http://www.arocha.org - the official website for A Rocha International
http://www.medwetcoast.com/article.php3?id_article=15- a description of Aammiq Marsh by MedWet Coast
http://www.wetlands.org/inventory&/MiddleEastDir/LEBANON.htm - Aammiq in "A Directory of Wetlands in the Middle East"
http://www.lebanonwire.com/0306/03061204DS.asp - an article on Aammiq Marsh, printed in a Lebanese newspaper
http://www.birdlifemed.org/Contries/lebanon/lebanon.html - a description of Aammiq Marsh by Birdlife International