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Development and Implementation of a
Pest Control Strategy for the
Hashimiyya Area in Jordan

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by

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and
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ACRONYMS

CCS	Council of Common Services
CDC	U.S. Centers for Disease Control and Prevention
EHP	Environmental Health Project
ELISA	enzyme-linked immunosorbent assay
ESRI	Environmental Systems Research Institute
GIS	geographic information system
HCA	Health Center Attendee
IDRC	International Development Resource Center
IUCN	International Union for the Conservation of Nature
JES	Jordanian Environmental Society
MOH	Ministry of Health
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
WAJ	Water Authority of Jordan
WHO	World Health Organization
WWTP	wastewater treatment plant

EXECUTIVE SUMMARY

Background

In August 1997, USAID/Jordan requested assistance from the Environmental Health Project (EHP) to assess pest problems associated with the As-Samra Wastewater Treatment Plant (WWTP). The WWTP is located in the Hashimiyya area, which covers six small municipalities. Established in 1985, the plant uses a stabilization pond system to treat most of the wastewater from Amman and Zarqa. It currently receives a daily average flow of 150,000 m^3/day—more than twice its capacity. The effluent from the plant is discharged into Wadi Dhuleil, a natural stormwater channel, and runs for about 13 km until it meets Wadi Zarqa and flows to the King Talal Dam Reservoir. Because of the high organic content of the effluent, significant mosquito and chironomid (nonbiting insects) breeding occurs in seepage areas or any place where water is stagnant.

The mosquito breeding season occurs from April to October and affects a population of 50,000. Because local residents complained about the pest problem, USAID requested that EHP carry out a preliminary assessment in August 1997, followed by a more detailed assessment in 1998, involving the development and implementation of a pest control strategy.

Scope of Work

The scope of work had four tasks:

- *Establishment of a pest abatement working committee.* The purpose of this task was to establish a working committee comprised primarily of community members and municipal officials, but to also include representatives from the Water Authority of Jordan (WAJ), the Council of Common Services (CCS), and the Ministry of Health. The function of the working committee was to serve as a coordinating mechanism among the stakeholders, act as an intermediary between the concerned institutions and the community, provide guidance in the development of the strategy, and eventually take responsibility for the implementation of the strategy. A committee of 23 members was formed, and it played a central role throughout the activity.
- *Clearing, shaping, and maintenance of Wadi Dhuleil.* The purpose of this task was to provide technical advice to WAJ in the development of an approach to Wadi clearance and maintenance. Clearing and maintenance is the key element of any strategy because if the Wadi is free of vegetation, has a rapid flow of water, and no stagnant pools, mosquito breeding will be minimized. Although a detailed survey of the Wadi was conducted, the recommended measures were not carried out because of a drastic reduction in WAJ's budget for Wadi maintenance.
- *Development of medium-term measures.* This task, which was by far the largest of the four, had three main components. The first was the collection of baseline data to define the problem and guide development of the strategy. The baseline data include the development of area maps to locate breeding sites, entomological surveys, a rodent infestation survey, a community assessment, a health assessment, and insecticide use and effectiveness assessment. The second component was the development of a pest control strategy. The strategy that was developed and implemented had three main parts: physical improvements to Wadi Dhuleil, the use of a biological pesticide (methoprene), and a public awareness campaign for household and community control measures. The third component was the development of a clear strategy for sustainability. The strategy was developed in June 1998 and implemented in the July-October period.
- *Study of options for piping/channeling of the effluent*. This task was canceled at the request of WAJ.

Results

The results of the activity are as follows:

- *Entomological results.* By September, once the physical improvements had been completed and methoprene had been applied regularly, the strategy resulted in an overall 98% reduction of mosquito breeding. Of the 15 sites regularly monitored, breeding was almost eliminated from all but two. In both of these sites, more physical improvements are needed. Overall, the monitoring of adult mosquitoes showed a reduction of 70 to 90%, depending on the site. Since the Wadi was practically free from mosquito breeding, it was determined that most of the remaining mosquito breeding was occurring in household cesspools. Breeding of chironomids also disappeared except for some breeding in the WWTP itself.
- *Community knowledge, attitudes, and practices.* EHP carried out a second round of data collection in November to determine the changes that had occurred from the community's point of view. The community reported a significant reduction in the density of insects, a 50% decrease in the amount of household spending on pest control measures, a decrease in the use of household insecticides, a greater awareness of the hazards of insecticide use, and a belief that the community could play an important role in controlling the problem. In contrast, the baseline assessment showed that the community did not believe they could do anything about the problem and that it was solely WAJ's responsibility.
- *Health assessment*. The health assessment confirmed a drop in mosquito bites from 57% to 15% and a significant decline in related health conditions such as skin allergies, nasal allergies, and unexplained headaches and fever.

Sustainability

The sustainability of the pest control strategy is dependent on five factors:

- Timely annual maintenance of the Wadi. It is WAJ's responsibility to provide the funding for Wadi maintenance, and this should occur in April each year.
- Regular treatment of breeding sites with methoprene. The community has a supply for the next two years, but will need financial support to purchase more in 2001 when the current supply runs out.
- Carrying out of institutional roles and responsibilities by the working committee, WAJ, and CCS.
- Proper sealing of the household cesspools with covers and screens for the vent pipes. Although the public awareness campaign focused on these measures, the working committee has a continued role in reinforcing these household behaviors.
- Regular monitoring of the larval breeding. Methoprene requires some laboratory monitoring, and although CCS is responsible for this, it may require outside assistance from the local university.

Conclusions and Recommendations

The activity determined the following:

- The approach to developing and implementing the pest control strategy was successful. The careful definition of the problem was key to developing the strategy.
- This activity and similar ones require a multidisciplinary approach involving entomologists, engineers, social scientists, vector control specialists, institutional specialists, and facilitators.
- The role of the community is critical to success. Engaging the community and helping people learn to take responsibility for the problem was perhaps the greatest success of the activity.
- The sustainability of the strategy is not yet assured because of two issues. One is whether WAJ will provide funding for timely annual maintenance of the Wadi. The second is future funding for methoprene. Both of these issues have been discussed with WAJ and USAID, but their resolution is not certain.

This activity demonstrated an approach to vector control that has applicability in Jordan and in other countries. It also reinforced the central role of the community in solving similar problems.

1 INTRODUCTION

1.1 Background

The As-Samra Wastewater Treatment Plant (WWTP), located in the Hashimiyya area, was established in 1985 to treat most of the wastewater that flows from Amman and Zarqa. The plant is a stabilization pond system that consists of three parallel trains. In each train, there are two anaerobic ponds, four facultative ponds, and four maturation ponds. The plant was designed to treat about 70,000 m^3/day, but at present it is overloaded and receives a daily average flow of about 150,000 m^3/day. The plant was recently upgraded with a number of emergency short-term improvements.

The effluent from As-Samra WWTP is discharged to a stream bed that runs 1.5 km before it discharges into Wadi Dhuleil. This effluent runs in a shallow channel in the Wadi for about 13 km to join with Wadi Zarqa, a major local river system that flows westward to reach the King Talal Dam Reservoir. The channel is about 3m wide and is maintained annually by the Water Authority of Jordan (WAJ) with the excavated material deposited alongside the channel to form beams that are 30 to 40 cm higher than the channel bed.

Originally, Wadi Dhuleil served as a natural stormwater channel for a very large catchment area, about 1,660 km^2 in size. However, except for a few winter storms, there is rarely enough stormwater to fill the Wadi. Many farms run the length of the Wadi and some rely mainly on the effluent of the WWTP to irrigate their crops. The farmers are allowed to use that effluent only to irrigate alfalfa, corn, and trees (basically olive trees).

Approximately 50,000 people inhabit the six villages and small towns in the Hashimiyya area, with the major portion (about 30,000) living in the city of Al-Hashimiyya. These localities are Khirbet As-Samra, Mazra'a, Al-Hashimiyya, Um-Suleih-Gharesa, Sukhneh, and Duqqara, and include the major part of the Municipality of Kori Beni Hashem. Except for Khirbet As-Samra, which lies about 1.5 km north of the WWTP, the localities border the Wadi as it runs westward towards the reservoir of King Talal Dam (see Figure 1 on page 7).

The residents of Al-Hashimiyya have complained about a range of pest problems that they believe are associated with the WWTP. These include mosquitoes, chironomids, sand flies, and rodents. At the request of USAID/Jordan, the presence of these pest problems was ascertained during an initial investigation carried out during late August and early September 1997 by Dr. Pandu Wijeyaratne from the Environmental Health Project (EHP) in communities around As-Samra WWTP. Investigators found mosquitoes, namely *Culex pipiens* and *Culesita sp.*, and chironomids breeding in the effluent of the WWTP all along Wadi Dhuleil where water stagnation, seepage, and vegetation exist. Large swarms of chironomids were also spotted at the WWTP itself and around houses in the area. Collection of outdoor- and indoor-biting insects revealed heavy infestation of *Culex pipiens* mosquitoes and a few sand flies. A moderate-to-heavy rodent infestation was also noted in Al-Hashimiyya, but the preliminary assessment did not find evidence to suggest that the infestation was related to the WWTP.

The Council of Common Services of Zarqa Governorate (CCS) is responsible for pest control in the Al-Hashimiyya area as well as in the rest of the Governorate. CCS sprays insecticides several times a year and the insecticides used are usually pyrethroids. The residents rely heavily on household spraying of insecticides and mosquito nets (40% of households) to alleviate the pest problem, often with minimal success. This puts an extra financial burden on the inhabitants there.

To remedy the situation, in December 1997 USAID/Jordan requested the assistance of EHP to develop a strategy to reduce mosquitoes and other pests associated with the As-Samra WWTP. The following were overall objectives of the EHP technical assistance:

- Develop a sustainable pest control program to reduce the number of biting insects and nuisance pests associated with the As-Samra WWTP including the effluent in Wadi Dhuleil.
- Develop the local capacity to implement and monitor the program during the course of this activity and after EHP assistance is finished.
- Reduce the number of biting insects and other nuisance pests associated with the As-Samra WWTP.

To achieve those objectives four tasks were identified :

Task A—Establishment of a pest abatement working committee

Task B—Clearing, shaping, and maintenance of Wadi Dhuleil

Task C—Development of a detailed work plan for medium-term measures

C.1 Baseline data collection
C.2 Development of safe, effective, and sustainable pest control strategies
C.3 Monitoring, training, and financial sustainability of programs

Task D—Study of options for piping/channeling effluent in Wadi Dhuleil

Although this report deals mainly with Task C, it also summarizes what happened in Tasks A and B. Task D is not summarized since it was cancelled at the request of WAJ.

1.2 Scope of Work for Tasks A, B, and C

Below is brief description of the scope of work for Tasks A, B, and C. Appendix A provides the detailed scope of work for the overall activity.

1.2.1 Task A—Working committee

The purpose of this task was to establish a pest abatement working committee. The working committee was comprised primarily of community members and municipal officials but also included representatives from the WAJ, CCS, and Ministry of Health (MOH). The committee was intended to serve as the primary mechanism for coordinating among the various stakeholders, to act as an intermediary between the concerned institutions and the community, to provide guidance in the development of the pest control strategy, and eventually to take responsibility for the implementation of the strategy over the long term. The scope of work called for the establishment of the working commitee and for strengthening its ability to carry out its functions.

1.2.2 Task B—Clearing and shaping the Wadi

The purpose of this task was to provide technical advice to WAJ in the development of an approach to Wadi clearance and maintenance. The cleaning and maintenance of the Wadi Dhuleil was considered an important measure that could significantly reduce the pest problem. Task B aimed at providing WAJ with a program of short-term measures, to be implemented in the summer of 1998, to clear, shape, and maintain the Wadi. This would keep it free from vegetation, ensure rapid water flow, and eliminate stagnant pools in which mosquitoes and chironomids breed. The scope of work called for a comprehensive survey of the Wadi including its physical characteristics, estimated flow rates, and areas of significant pooling. Based on this assessment, EHP was asked to make recommended improvements including design drawings to reshape the Wadi.

1.2.3 Task C—Development of medium-term measures

The initial investigation identified a number of medium-term measures in addition to physical improvements to Wadi Dhuleil that could mitigate the pest problem. Before a pest control program could be developed, additional investigation was needed.

C.1 Baseline data collection

Baseline data collection consisted of the following :

- Area maps to locate all sites of significant

insect and pest breeding and control
- Entomological surveys to provide a basis for measuring the effectiveness of control efforts
- Rodent infestation survey to determine the extent of infestation and control measures
- Community assessment to assess knowledge, attitudes, and practices of nuisance insects and other pests, identify coping strategies, and determine opportunities for community involvement in control measures
- Health assessment to determine community health status related to insects and other pests
- Insecticide use and effectiveness assessment to determine susceptibility of adult mosquitoes and larvae to insecticides

C.2 Development of safe, effective, and sustainable pest control strategies

Based on the results of the baseline data collection, an effective and sustainable pest control program was developed. The following approaches were considered in developing the control program:

- Clearing and shaping of Wadi Dhuleil to minimize seepage and maximize the flow of water
- Larvicidal program including safe biological larviciding
- Chemical insecticiding if used selectively and judiciously by the municipality and homeowners
- Livestock relocation if it is determined that livestock can serve as a barrier between the mosquito breeding sites and the community
- Rodent control if the baseline study determines that As-Samra has an impact on the presence of rodents in the community
- Bednets if they offer the possibility of relief before the insect problem is brought fully under control

C.3 Monitoring, training, and financial sustainability programs

EHP was asked to assist in developing the means to monitor the effectiveness of the pest control program over the long term, training the appropriate personnel to implement the program, and ensuring that a plan is in place to provide the financial resources to implement the program after USAID assistance is no longer available.

1.3 Role of the Working Committee

As explained in Section 1.2.1, one of the key tasks was to establish a working committee to guide the overall effort and coordinate related activities of WAJ, CCS, and the MOH. The working committee was seen as the primary mechanism to involve the community in the development and implementation of the activity. The committee that was established consisted of 23 members including four mayors, three municipal employees, three teachers, three health professionals, three farmers, two managers from local industries, three from WAJ, one from the MOH, and one from CCS. The city engineer from Al-Hashimiyya was the initial executive director and when he changed jobs and moved, he was replaced by the mayor of Um-Suleih.

EHP organized an initial meeting in December 1997 to propose the idea of creating a working committe and agree on the membership. In February 1998, EHP organized a two-day workshop to establish the committee. The workshop resulted in agreement on the overall mandate and the functions of the committee, the organizational structure, roles and responsbilities, and by-laws. The committee agreed to meet monthly to review activities. These meetings were always attended by the EHP in-country team leader and USAID. The meetings were usually scheduled so that U.S. or Jordanian consultants could seek concurrence on an activity or provide a debriefing on work recently completed. Nothing was done without the concurrence of the committee. In July 1998, a second two-day workshop was held for the working committee to develop the pest control strategy. The working committee continued to meet approximately monthly to review progress, resolve problems, and guide the work of the consultants. In February 1999, EHP organized a one-day wrap-up workshop to review the results, discuss steps that needed to be taken to ensure the sustainability of the effort, and provide closure to the activity.

From the outset, it was intended that the working committee would be ongoing and oversee the implementation of the strategy each year. EHP's intention was to place the responsibility for

ensuring implementation of the pest control strategy squarely on the community. Clearly actions would be needed from WAJ and CCS, but the objective was to have community members ensure that these occurred. This was particularly important since the residents are accustomed to waiting for others to take action rather than taking responsibility themselves.

1.4 EHP Team

The activity was carried out primarily by Jordanian consultants although some targeted technical assistance was also provided by U.S. consultants. The in-country team leader was a highly qualified medical entomologist from the University of Jordan. The two other key local consultants were a physician/entomologist from the Jordanian University of Science and Technology for the health assessment and a social scientist from Al-Imran for the community assessment. In addition to these three principal consultants, a number of local consultants, including an engineer, a facilitator, a social science research specialist, a rodent control specialist, and a mid-level entomologist, carried out activities. EHP also contracted with the Jordanian Environmental Society to conduct a communications campaign.

The U.S. consultants included two directors of mosquito control districts in New Orleans and Baton Rouge, Louisiana, an engineer who carried out a physical assessment of the Wadi, and a facilitator for the first two working committee workshops. Overall guidance and supervision were provided by two EHP staff members—the Technical Director for Tropical Disease and the Technical Director for Institutional and Human Resources Development.

A list of the consultants and their roles is provided in Appendix B.

1.5 Organization of the Report

This report is organized into six chapters. Chapter 2 summarizes the resuts of the assessments. Data were collected to establish a baseline as well as to provide information to design a pest control strategy. Baseline data were collected in the areas of entomology, health, community, and rodents. Chapter 3 describes the pest control strategy that was developed after all the assessments were completed. Chapter 4 presents the results achieved after implementation of the strategy. Chapter 5 summarizes the strategy for monitoring effectiveness of the strategy in the future and other key elements of sustainability. Chapter 6 includes recommendations and next steps.

2 ASSESSMENT

2.1 Entomological Data

2.1.1 Mosquitoes and chironomids

Objectives

The objectives of this activity were to determine the following:

- The species of mosquitoes and chironomids that breed either in the WWTP or its effluent as it is carried by Wadi Dhuleil and Zarqa River. The area of study extends from the WWTP to about 1 km west of Duqqara village, Kora Beni Hashem, in the Hashimiyya area.
- The potential and actual breeding sites of the recorded mosquitoes and chironomids in the area.
- The density of the immature stages of mosquitoes in breeding sites in the area prior to any control activity.
- The species of mosquitoes that attack people in houses and when such attacks occur.
- The most suitable strategies for combating mosquitoes and chironomids.
- The degree of mosquito susceptibility and resistance, if any, to groups of insecticides used regularly by the inhabitants in Al-Hashimiyya to combat adult mosquitoes that bite indoors.

Methodology

A team of EHP entomological consultants identified the potential breeding sites of mosquitoes and chironomids in the Al-Hashimiyya area during April 1998. While walking the length of the 15 km stretch of the Wadi, the team used a standard mosquito dipper to examine the sites on 11 April and 15 June 1998 for breeding of mosquitoes and chironomids. Fifteen of those sites were later chosen for regular monitoring (see Figure 1).

Once sites were identified, mosquito breeding was investigated biweekly using standard dippers. During the investigation, the team conducted four dips at each site and determined the number of larvae and pupae per dip (350 ml). The immature stages were returned to the site except at the last dip, which was poured into a plastic bag and transported to the laboratory for species identification. Mud and algae also were examined for the presence of the red larvae of chironomids. Because their distribution was not homogenous in mud and algae masses in which they were lodged, no regular counting of chironomid larvae was carried out.

In addition to the above-mentioned methods to study the population of mosquitoes, the human-landing rates of mosquitoes were also determined during late May and June 1998. Trained MOH field workers helped with this activity. They worked in pairs, one indoors and the other outdoors, collecting mosquitoes that attempted to bite them. They usually started collecting mosquitoes at sunset and continued for three hours. One night they worked until dawn. The workers exchanged places every hour. A light torch was used to help each worker spot the insects. The insects collected every hour were placed in separate vials for further identification.

To study mosquito resistance to insecticides, *Culex pipiens* larvae and pupae collected from the field and reared in the laboratory were exposed to standard doses of the following insecticides: fenthion, malathion, baygon, and permethrin.

Results

Species of mosquitoes and chironomids breeding in the study area

The investigation determined that four species of mosquitoes breed in Wadi Dhuleil in the Al-

Hashimiyya area. These are *Culex pipiens, Culex sinaiticus, Culex laticinictus,* and *Culiseta longiareolata.* All of these species usually feed on animals while only the first mentioned also feeds on humans. Laboratory rearing of this species showed that the females are autogenous; they lay the first batch of eggs without a blood meal. Thus, this species is properly identified as *C. pipiens molestus.* At least one species of chironomids, *Chironomus plumosus,* breed in the area.

Potential breeding sites of mosquitoes and chironomids

The survey revealed 61 potential breeding sites for mosquitoes and chironomids (see Figure 1). Five were located at the WWTP and the rest were located along the course of the Wadi up to about 2 km after it meets the Zarqa River.

Four of those sites were within oxidation ponds at the WWTP. Site 5 was a seepage area 50 m from a pumping station at the plant. Sites 6 to 61 were located along the effluent course; Sites 6 to 42 were within a 6 km stretch near the town of Al-Hashimiyya; and the remainder covered the remaining 9 km of the Wadi running westward and passing by Um-Suleih, Sukhneh, and Duqqara (Kora Beni Hashem).

Some of the sites were small (2x1 m) whereas others were large, stagnant water bodies that resulted from water seepage. Some extended about 100 m long by several meters wide. A detailed description of those sites is included in Appendix C.

When surveyed in early April 1998, only two of the 61 sites (5 and 35) had mosquito larvae, mainly *Culiseta.* By mid-June when all the potential sites were surveyed again, five sites (4, 5, 9, 33, and 57) were dry. No mosquito breeding was noted in Sites 1, 2, 3, and 5A (oxidation ponds) nor in Sites 42, 45, and 52. The other sites had mosquitoes and chironomids breeding there—19 sites had *Culex* and *Culiseta* mosquitoes, 22 had only *Culex*, mainly *Culex pipiens.* The density of mosquitoes in those sites was estimated rather than specifically determined. Twenty-two of the sites had 200 to 300 immature stages per dip. On the other hand, chironomids were noted breeding in the oxidation ponds as well as in most of the sites along the Wadi. Algae and bottom mud taken from the Wadi often contained more than 100 chironomid larvae per dip.

Monitoring of breeding of mosquitoes

The team began regularly monitoring the 15 assigned sites in mid-May 1998. No breeding was noted in the oxidation ponds (Sites 1, 3, and 5A) nor in Sites 8 and 54 (see Table 1). In the other sites, breeding of mosquitoes was very low except for Site 56. In Sites 11, 30, 34, 39, 58A, 59, and 61, the mean number of immature stages (larvae and pupae) per dip ranged from < 1 to 14 (see Table 1); it was only 54 at Site 51A but high (723/dip) at Site 56. Toward the end of May, Sites 30 and 51A showed moderate numbers of immature stages (118 and 106/dip, respectively). Table 1 shows the results of the monitoring during the April-October period.

However, by 10 June 1998, most sites showed heavy breeding of mosquitoes with means exceeding 500/dip. In Sites 30, 34, 35, and 39 (in the town of Al-Hashimiyya), the mean numbers of immature stages of mosquitoes were 733, 1,378, 518, and 814/dip, respectively. Most of these mosquitoes were of the *Culex pipiens* type, which could attack people outdoors and indoors. Some dips had 3,000 to 4,000 larvae and pupae.

Because the Wadi was heavily infested with immature stages of mosquitoes, and area residents repeatedly complained (according to the mayors), the CCS conducted its regular control activities, which had been halted so as not to adversely influence the base line survey. On 17 June, CCS proceeded to fog the area with pyrethroids as well as spray the sides of the Wadi with diesel oil and pyrethroids.

Figure 1
Map of Al-Hashimiyya Area

A reduced copy of the GIS map will go here.

Table 1
Mean Number of Immature Stages (Larvae and Pupae) of Mosquitoes per Dip (350 ml) at the Different Monitoring Sites

Site #	11/4	14/5	28/5	10/6	25/6	16/7	30/7	13/8	27/8	10/9	24/9	12/10	26/10
1	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-
5A	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	1	812	19	-	-	< 1	-	-	-	-
11	-	< 1	-	334	0.3	Dry	-	-	-	-	-	-	-
30	-	4	118	733	1369	46	Dry	-	-	-	-	-	-
34	-	7	28	1378	147	Dry	Dry	-	-	-	-	-	< 1
35	+	< 1	17	518	351	215	Dry	360	< 1	76	277	62	81
39	-	7	2	814	22	159	Dry	-	-	-	-	-	-
51A	-	54	106	120	97	56	78	108	18	369*	284*	163*	501*
54	-	-	1	68	278	Dry	-	< 1	21	2	515*	-	2
56	-	723	136	588	350	150	72	163	222	68	23	6	-
58A	-	2	9	202	224	148	42	80	< 1	76*	-	-	-
59	-	14	< 1	16	-	111	36	27	31	157*	5	-	-
61	-	< 1	2	234	433	134	433	24	13	65*	22*	8	-

* > 80% are *Culex sinaiticus*

Human-landing rates of mosquitoes

As expected, the female mosquitoes, which were *Culex pipiens*, attacked people indoors and outdoors from sunset until dawn.

The number of *Culex pipiens* females coming to feed within three hours after sunset on human volunteers at the assigned site in Al-Hashimiyya is presented in Table 2. The mean number of mosquitoes per person per hour ranged from 20 to 47 during June 1998, but lower numbers were recorded in late June. On the other hand, much higher numbers were recorded in Um-Suleih where cesspools are mainly used for disposal of liquid wastes (see Table 3). The numbers peaked on 11 June when the mean numbers of mosquitoes per person per hour were 141 and 112 in indoor and outdoor catches, respectively. The maximum number per person per day was 155. Because of the growing complaints of the people, the municipality of Um-Suleih carried out a fogging campaign with pyrethroids at sunset on 25 June 1998, just before the workers started their mosquito-collecting activity. That undoubtedly had an adverse effect on the nighttime mosquito population where the mean number was 29 per person per hour.

Susceptibility of mosquitoes to groups of insecticides used for control

The absence of baseline data on the tolerance of a susceptible Jordanian strain of *Culex pipiens* to different groups of insecticides led to a comparison with data obtained in the United States for susceptible strains of *Culex pipiens* mosquitoes exposed to identical concentrations of the same insecticides. Thus far, the findings are not conclusive. However, the preliminary results suggest some degree of tolerance or resistance of the Jordanian *Culex pipiens*, at least to pyrethroids, as represented by permethrin. Pyrethroids is the active ingredient in the most common commercial aerosols used by the homeowners in the area to control adult mosquitoes. Live specimens of this mosquito species are being reared by Dr. Mike Carroll in the United States for further susceptibility studies.

2.1.2 Sand flies

Although sand flies are not directly associated with the effluent from As-Samra, many community members believe they are. When people are bitten, they often do not know if it was a mosquito or a sand fly. For this reason, the working committee requested EHP address this issue. In response, EHP agreed to do a simple rapid assessment of sand fly breeding to determine possible breeding sites and potential actions.

Table 2
Human-Landing Rate of *Culex pipiens* Coming to Bite Humans in Al-Hashimiyya

Date	No. of Mosquitoes* per Person per Hour	
	Indoor	Outdoor
21 May 1998	8	14
4 June 1998	47	20
18 June 1998	24	36
25 June 1998	22	23
17 September 1998	3	1
13 October 1998	2	< 1

* Mosquitoes were collected for three hours after sunset.

Table 3
Human-Landing Rate of Culex pipiens Coming to Bite Humans in Um-Suleih Village, Al-Hashimiyya Area

Date	No. of Mosquitoes* per Person per Hour	
	Indoor	Outdoor
28 May 1998	19	61
9 June 1998	61	51
11 June 1998	141	112
25 June 1998**	29	28
3 September 1998	58	60
17 September 1998	9	9
13 October 1998	1	9

* Mosquitoes were collected for three hours after sunset.
** Fogging was carried out in the evening by the Municipality of Um-Suleih.

Objective

The objective of this activity was to determine the species of sand flies present in and around houses in the Al-Hashimiyya area and their possible breeding sites.

Methodology

Sand flies were collected weekly during a 28-day

period in July and August 1998 using A4 papers covered with caster oil as sticky traps. Five traps were placed, indoors and outdoors, in each of the three houses selected at Al-Hashimiyya, Um-Suleih, or Sukhneh. A total of 15 traps was also placed in each of the three localities every night. Seven traps were also placed at a cattle farm located midway between Al-Hashimiyya and Sukhneh. Traps were collected the next morning and were transferred to the laboratory for species identification.

Collected sand flies were processed using standard techniques (Lane, 1986) and were identified using the keys of Theodore (1958) and Lane (1986), employing the morphology of the spermathecae and cibarial and pharyngeal armatures for females and the morphology of external genitalia of males.

Results

Four species of sand flies, *Phlebotomus papatasi*, *Phlebotomus sergenti*, *Sergentomyia dentata* group, and *Sergentomyia tiberiadis* were collected from the study area. The first two species feed on man and animals and are known as vectors of cutaneous leishmaniasis, which is endemic in areas a few kilometers to the east of the Hashimiyya area. The former species is also known as a vector of sand fly fever virus. The *Sergentomyia* species feed on animals and do not transmit disease to man. *Phlebotomus papatasi* was the most common species collected and was found in all localities surveyed while *Phlebotomus sergenti* was collected mainly from Sukhneh and, to a lesser extent, from Al-Hashimiyya and the cattle farm. Both species were collected indoors and outdoors.

A large number of *Phlebotomus* sand flies (99 out of 132) collected from houses in the area were males. Because the insect is a weak flier, this indicates that the breeding sites were located very close to houses. Many houses in the Al-Hashimiyya area, especially in Um-Suleih, had animal sheds sheltering goats, sheep, and chickens adjacent to the houses. The manure present in these sheds constitutes a very suitable breeding site for larvae of sand flies.

2.2 Social Assessment

The social assessment was conducted May to June 1998. The main purpose of this assessment was to generate an information base related to the nuisance pest problems associated with As-Samra that could be used to develop a control strategy.

2.2.1 Objectives

The objectives of the social assessment were as follows:

- Reach an understanding of the current community status of knowledge, attitudes, practices, and beliefs in relation to the nuisance problem
- Identify the community role in the implementation of the control measures
- Determine the willingness of the community to participate in the control measures

2.2.2 Data Collection

Data for the social assessment were collected through focus group discussions, a household survey, and interviews with key informants. The 14 focus groups lasted one and a half hours and were held in five communities (Hashimiyya, Um-Suleih, Al-Sukhneh, As-Samra, and Al-Mazra'a) and in Kori Beni Hashem, with separate groups of men, women, boys, and girls. In addition, one focus group consisted of farmers. The household survey included 250 households and was implemented in the same five municipalities. The primary criteria in selecting the location and size of the household sample was the proximity to Wadi Dhuleil and the size of the population. A larger percentage of the sample was drawn from Al-Hashimiyya and Al-Sukhneh. Key information interviews were held with mayors, school directors, teachers, the CCS engineer, WAJ Director of Planning, the Director of Public Awareness in the Ministry of Water and Irrigation, and shopkeepers.

2.2.3 Results

The following summarizes the main findings of the social assessment.

- *Awareness of the problem.* People in the

community were well aware of the problem and its causes. Mosquitoes and sand flies were the most prevalent insects. All people recognize sand flies, but most of them do not distinguish between mosquitoes and chironomids. All the municipalities in the area were suffering from the problem regardless of how close they were to the Wadi or the WWTP and whether or not they had cesspools.

- *Seasonality*. Summer is the worst season for insect attacks in the area, when mosquitoes and sand flies become very active. The highest percentage of insect attacks occurred from 11 p.m. to 4 a.m., followed by the time from sunset until 10 p.m. The attacks occurred indoors and outdoors.
- *Breeding sources.* The community perceives the WWTP to be the main source of breeding for pests, including mosquitoes and sand flies. Almost half perceive the vegetable farms and animal barns and their manure to be breeding sites for mosquitoes and sand flies. Only one-quarter believe Wadi Dhuleil to be the source of breeding for mosquitoes.
- *Health impact*. Almost two-thirds of the respondents in the household survey reported suffering from a variety of health problems that they attribute to the pest problem. These problems include allergic reaction to bites, skin allergies, high fevers, and skin blisters. One-half of the respondents report negative health effects after fogging.
- *Economic impact*. Spending on household insecticides and other household control measures such as nets, fans, and screens represent a financial burden to the community. Families typically spend between 5 and 10% of average monthly household income (JD 150) on control measures. One-quarter of the respondents reported they spend US $15 per month on household insecticides alone. (The conversion rate is JD 150 per US $1.)
- *Social impact*. Almost half of the respondents report that the mosquito problem is affecting their social life. They cannot sit outside without a net at night or eat outside. Families sleep under one net at night. One-third report difficulties sleeping.
- *Household control measures.* Families use a variety of houshold control measures, the most effective and expensive being insecticides (54%). Nets are an effective method, especially for sleeping, for 42%. As much as 85% use screens on windows and doors. Only 11% use fans because of electricity costs and 24% use vape. Some also report using traditional measures such as putting olive oil in a tray to attract insects, cleaning the house with kerosene or diesel fuel, mixing detergents with kerosene to clean, and burning wood to drive away insects.
- *Rodents.* People in the area complained about rats but to a lesser extent than mosquitoes. The main causes for this problem are perceived to be the sewer system, food waste and garbage, and animal farms and barns.
- *How to solve the problem*. People believe that WAJ and rich people from Amman are the main cause of the problem and that WAJ is doing nothing to solve it. Although mayors believe that it is their responsibility to reduce suffering, they lack the resources to do very much. They rely on CCS to control mosquitoes by spraying.
- *Willingness to participate.* People in the area expressed their willingness to participate in solving the pest problem provided an effective strategy is in place and it will not cost them money. However, 53% said there is nothing they can do to control mosquitoes, and 56% said they are not willing to do anything to solve the rodent problem since they believe it is the government's responsibility.

2.3 Health Assessment

The purpose of this activity was to document any health problems that might be attributable to pests associated with the WWTP.

The specific objectives were as follows:

- To assess the magnitude of the nuisance problem such as lack of sleep, anxiety, and social embarrassment
- To assess the magnitude of the dermatological effects resulting from insect bites
- To explore the possibility of causing arboviral infections in the community, namely, West Nile, Rift Valley, and sand fly fevers
- To study the possible adverse health effects of the community's exposure to insecticides

2.3.1 Approach

To achieve the above objectives, the following approaches were used.

Health Center Attendees (HCA): All attendees to the Hashimiyya Housing Health Center during the period from 20 June to 31 July 1998, were invited to participate in the study. The total number of participants was 664. Each participant was subjected to the following procedures, after informed consent.

Interviews: A trained female interviewer conducted personal interviews with each participant using a semi-structured questionnaire prepared specifically for this study. Information collected included beliefs about the health effects of the WWTP, past history of related diseases, presence of animals in or near the house, period of residence in the area, distance from the WWTP, and indicators of socioeconomic status. Relevant information regarding children were obtained from the person accompanying the child. Questions about beliefs were not applicable to children. Table 4 shows the results of this questionnaire.

Physical examination: Each subject was given a physical examination by one of the two general practitioners in the health center or by the investigator himself. Pest and pesticide-related conditions were emphasized.

Blood samples: A blood sample of 10 cc was obtained from all 267 participants. Children under five years of age were excluded from this procedure. The samples were kept in an ice bag and transported to the laboratory the same day they were collected. The blood was immediately centrifuged and the serum separated into two tubes and stored at -20EC. The sera were transported to Egypt in an ice bag, accompanied by the investigator in October 1998, where they were analyzed in the U.S. Naval Medical Research Unit No. 3 (NAMRU-3) laboratories. Analyses included the following:

- Immunoglobulin (IgG) testing for Rift Valley, West Nile, sand fly Sicilian, and sand fly Naples viruses
- Immunoglobulin (IgM) testing for evidence of acute infection with the above viruses

Immunoglobulins were determined using the enzyme-linked immunosorbent assay (ELISA).

Review of medical records: A sample of 1467 records was randomly selected and abstracted, using a special form prepared for this study. Any relevant conditions and their date of diagnosis were recorded.

2.3.2 Results

- As in the social assessment, the findings indicated that the quality of life of residents was markedly influenced by the WWTP. Nuisance was a uniform complaint, and its sources were a bad smell, mosquitoes, flies, and rats. The vast majority of people believe that the WWTP is a health hazard.

Table 4
Sociodemographic Characteristics of the Sample of Health Center Attendees

Variable	Number	Percent
1. Age (mean=20.9 Y, SD=17.3)		
< 5	143	22.2
5-9	65	10.1
10-19	149	23.1
20-29	108	16.8
30-39	77	12.0
40+	102	15.8
2. Sex		
males	226	35.2
females	416	64.8
3. Monthly family income (mean=162.7, SD=91.6)		
<100	98	15.2
100-249	457	71.0
≥249	89	13.8
4. Presence of animals		
in house	176	27.5
near house	49	7.6
far away	416	64.9
5. Distance from the plant		
2 Kms or less	295	47.3
> 2 Kms	329	52.7
6. Period of residence (mean=12.0, SD=7.3)		
< 5 Y	131	20.6
5-10	184	28.9
11+	321	50.5
7. Insecticides spending (mean=11.2, SD=7.3)		
<10 JDs	293	48.1
≥10	316	51.9

Over 40% had a history of skin diseases, 63% complained of lack of sleep, and more than 25% had a history of nasal allergy (see Table 5). At the time of examination, 57% of the subjects had evidence of mosquito bites and 11% had nasal allergy (see Table 6).

- Serological tests showed that 7.9% had been exposed to West Nile fever virus, 46% to sand fly Sicilian fever virus, and 29.2% to sand fly Naples fever virus. These infections have never been reported in Jordan before. Evidence of viral infections was higher in females than males and seemed to be associated with the presence of animals and proximity to the WWTP. The absence of acute infections of these viruses at the time of examination indicates that previous epidemics are responsible for the current seroprevalence. The study also showed no evidence of Rift Valley virus in the studied population.

Table 5
Health Problems to which Subjects Had Previously Been Exposed as Reported by the Sample of Health Center Attendees

Health Condition	Number	Percent
Skin diseases	190	41.7
Insomnia	288	63.0
Cancer	1	0.2
Diarrhea	78	17.1
Anxiety	84	18.5
Fever	72	15.8
Worms	13	2.9
Poisoning from insecticides	3	0.7
Hepatitis	4	0.9
Nasal allergy	120	26.3
Asthma	15	3.3
Others	75	16.5

Table 6
Clinical Diagnoses of Health Center Attendees

Health Condition	Number	Percent
Skin problems		
mosquito bites	372	57.2
eczema	12	1.9
urticaria	11	1.7
allergy	3	0.5
combinations	40	6.2
Nasal allergy	69	11.2
Fever	48	7.8
Diarrhea	31	5.0
Asthma	9	1.5
Anxiety	5	0.8
Insomnia	4	0.6
Hepatitis	1	0.2
Others	436	70.0

Note: Percentages do not total 100% because subjects may have more than one health problem.

2.4 Rodents

2.4.1 Objective

The objective was to determine the extent of rodent infestation and whether the WWTP and its effluent in Wadi Dhuleil have an impact on the presence of rodents in the community.

2.4.2 Findings

Preliminary findings by the EHP consultants indicated that rodents were present in Al-Hashimiyya along Wadi Saedeh and close to houses. Garbage and food refuse left along the Wadi embankment and in the streets and around houses constituted the main source of food for these rodents. Rodent burrows were also noted in mud embankments adjacent to poultry houses. Rodents were apparently feeding on stored poultry food and open feeding stations in poultry houses.

No rodents were found to be associated with Wadi Dhuleil or the WWTP.

Further surveys carried out in collaboration with experts from the Greater Amman Municipality confirmed the earlier findings that no rodents were associated with either the WWTP or the Wadi. These experts also concluded, based on the consumption of baits placed at different localities at Al-Hashimiyya and the active inspection of manholes and burrow sites in the town, that there was a moderate to heavy rodent infestation in Al-Hashimiyya and that the primary cause was improperly disposed of solid waste in the area.

2.5 Mapping

As part of the assessment phase, EHP hired Infograph, a local Geographic Information System (GIS) firm, to develop maps of the areas, using GIS software. The purpose of the maps was to help planning efforts by all those concerned with the pest control program by offering a better understanding of the spatial distribution of the shape and course of the Wadi as well as the location of the pest problem areas and associated factors. This work was divided into two phases.

Phase I

The local firm automated the following layers from hardcopy maps at scales 1:25,000 and 1:7,500, using table digitizing and GIS software. The automated data layers were then cleaned from errors, verified for consistency, and their topology constructed. They were also registered in real coordinates (Cassini Coordinate System) and edge-matched as monolithic layers. In addition, annotation text was added in English for major landmarks, Wadis, and geographic areas.

The above operations were performed using PC ARC/INFO and workstation ARC/INFO GIS systems of Environmental Systems Research Institute (ESRI), Redlands, California. The data were delivered as a set of topologically built and cleaned PC ARC/INFO coverages in real coordinates.

A set of hardcopy colored maps covering the project area (147 sq. km) and encompassing all the layers mentioned above was designed and generated. The maps were plotted using a four-pen color plotter on a stable material. Two sets of maps (total of four map sheets), which were plotted at a scale of 1:10,000, were delivered. EHP used the maps in Phase II to add details such as pest locations and points of environmental hazards.

Phase II

EHP used the hardcopy plots produced in Phase I above in the field to mark point features of potential (mosquitoes) breeding sites, potential breeding and monitoring sites, and adult trapping sites. A digital GIS layer of these point features was produced (digitized). In addition, EHP requested updating some of the basemap layers with features observed in the field (e.g., bridges and new roads).

The final maps that included the added point locations, attribute information as table insets, and basemap updates were designed and generated. The final maps were plotted at a scale of 1:10,000 on stable material and were laminated. Each municipality was provided a copy of these laminated maps for planning and monitoring purposes.

2.6 Physical Assessment

Under Task B, EHP carried out a detailed physical assessment of the Wadi. The survey showed that, due to the natural geomorphologic form of the Wadi bed, there were two to three parallel channels in the Wadi despite the preparation of a single channel for the effluent. The prepared channel was formed primarily by placement of berms of rock and soil alongside the channel alignment, with minimal excavation of rock or soil from the channel bed. Thus, the effluent water level in the prepared channel in many places was higher than the adjacent Wadi bed level. This meant that a simple breach of the berm would allow water to flow laterally to form side streams and pools that serve as insect breeding sites.

The physical assessment resulted in three recommendations for short-term improvements:

- *Elimination of side streams and pools*. This involved deepening and widening the prepared channel sufficiently so that the water level in the prepared channel would be below the level of the adjacent Wadi bed. Since the estimated cost of excavating the entire reach

(nearly 15000 m) would greatly exceed the funds allocated by WAJ (more than JD 200,000 compared to an initial fund of JD 70,000), the consultant team decided to divide the Wadi into four priority categories to be excavated as funds permitted. The recommendation was to excavate Priorities A and B—areas where the existing channel was not lower than .5 m below any other point in the Wadi—in 1998. The estimated cost of excavating the two subreaches was JD 84,000.

- *Filling in pools by bridges*. In several places, pools forming near bridges and culvert abutments were breeding sites. The consultants suggested filling in these pools with a well-graded mixture of stone and gravel.
- *Clearing of vegetation*. The process of excavating the channel would uproot most of the established vegetation. Stopping the flow of water to streams and pools would inhibit the growth of vegetation as breeding sites outside the prepared channel. If vegetation is observed growing along the banks of the prepared channel, it should be cleared as part of annual maintenance.

Budgetary problems facing WAJ reduced the funds allocated for the clearing of the Wadi to less than JD 10,000 (only JD 15,000 was allocated for all WWTPs in Jordan). The result was to abandon the suggested plan for clearing and straightening Wadi Dhuleil as called for in Task B, but use it as a guideline for any clearing and shaping that might be done as funds became available. Chapter 3 describes the physical improvements that actually took place.

3 PEST CONTROL STRATEGY

After the assessments described in Chapter 2 were completed, EHP organized a workshop that included the key Jordanian and U.S. consultants, WAJ, MOH, USAID, and representatives of the working committee. The results of the assessments were presented and a pest control strategy was developed. The strategy had three components. The first was physical improvements to Wadi Dhulei; the second, the use of a biological larvicide; and the third, a community and household public awareness and education campaign. Each of these components is described in detail in this chapter.

3.1 Physical Improvements

3.1.1 Strategy

The main activities in this strategy were the following:

- Prepare and implement an action plan to deepen, clear, and shape Wadi Dhuleil so that water will not seep and form pools of stagnant waters where mosquitoes and chironomids can breed; water will move fast enough to prevent mosquito and chironomid breeding; and vegetation present at the edges of the water course will be removed
- Fill in the seepage areas along the Wadi

To implement the plan, CCS and WAJ were to provide equipment (bulldozers, loaders, and trucks) and the personnel needed to carry out the activity under the guidance of the city engineer of Al-Hashimiyya. Blockage of seepage area would take priority, to be followed by clearing of the Wadi, especially in Al-Hashimiyya where breeding was the heaviest. It was agreed that the working committee would contact the Governor of Zarqa to ensure assistance from other sources (i.e., Ministry of Public Works and the Jordanian Armed Forces), which would speed up the shaping and clearing campaign to coincide with the biological control activities. The Municipality of Al-Hashimiyya would request building contractors to dump excess material at certain spots along the Wadi to be used to fill in seepage areas.

3.1.2 Implementation

The activities carried out included the following:

- Closing seepage areas
- Filling in certain sites with dirt where seepage water became stagnant
- Deepening of watercourse along the Wadi
- Removal of grass growing along the Wadi course
- Rechanneling the water at certain areas to avoid curbs and sharp bends
- Changing the location of some pumps that farmers had placed in small pools created along the channel

CSS provided the major part of the work (65%). WAJ contributed approximately 25% of the effort, and a volunteer private contractor carried out the remaining 10%.

Schedule of activities :

July 4-11
- Closing seepage areas in Al-Hashimiyya and in one area Between Um-Suleih and Sukhneh (Site 54 to Towel Paper Factory)

July 11-22
- Shaping and widening the Wadi at WWTP outlet (carried out by WAJ) and Site 6 to Site 39 (carried out by CCS and WAJ)
- Adding dirt to cover areas with stagnant water (Sites 10-12 and Sites 30-34; carried out by CCS)

August
- Rechanneling the Wadi at Al-Hashimiyya

(Sites 30-35; carried out by CCS, WAJ, and private contractor) and shaping the Wadi from Site 42 to Site 54 (CCS and WAJ)

September 1-8

- Shaping the Wadi from Site 57 to 59 (WAJ)

September 9-20

- Completing shaping of the rest of the Wadi to about 2 km west of Site 61

3.2 Biological Control

3.2.1 Strategy

The strategy initially involved regular application of the chemical Bti, in the form of impregnated corn cob granules (trade name "VectoBac G"), to the Wadi. The chemical is a toxin produced by a strain of the bacterium, *Bacillus thuringiensis.* The rate of application was 22kg/hectare. It was decided to apply the chemical for six weeks every three to seven days based on monitoring results. To achieve proper application, the workers who were assigned by CCS and the municipalities to apply the chemical were trained in how to estimate the area to be treated, the quantities to be added per area, the application means, and procedure and safety precautions. To ensure its effectiveness under existing field conditions, a pilot application of the chemical was carried out, and it was confirmed that Bti was, as expected, effective against *Culex pipiens* mosquitoes.

Because of the discovery of dense vegetation along the Wadi that could minimize the effectiveness of Bti and drift problems associated with the floating granules of Bti, the strategy was changed and the chemical, methoprene, replaced Bti as of 31 August 1998. Methoprene is a juvenile hormone analogue that controls breeding of both mosquitoes and chironomids in sewage effluent. As with Bti, the workers received proper training in its application. The application schedule was every 21 days from the end of August until the end of October. Both larvicides are approved by the U.S. Environmental Protection Agency and were explicitly accepted for use in this activity by USAID.

The strategy also involved monitoring the effectiveness of biological control activity. The Wadi was regularly visited, before and after treatment, and the breeding of mosquito larvae was checked using a standard dipper. CCS was informed if monitoring indicated inadequate treatment.

3.2.2 Implementation

Two chemicals, Bti (VectoBac G) and methoprene (Altosid pellets), were used. Bti was applied at a rate of 2 gm per square meter from 12 July 1998 until 22 August (see Table 7). When monitoring revealed poor application or inadequate control, sites received more than one round of treatment within a three-day period. This was true of Sites 30, 51A, 50, and 61 on one or two occasions.

The presence of dense vegetation at the sides of the Wadi and the rate of flow of the sewage effluent caused Bti to be less effective than expected, and, as a result, it was replaced by methoprene by the end of August.

Methoprene, in the form of Altosid Pellets, was applied every three weeks at a rate of 1 g per square meter (25 g per 25 square meters of area). The treatment was carried out every 21 days as outlined in Table 7.

Table 7
Treatment Schedule for Vectobac G and Methoprene

Date of application	Dosage
Vectobac G	
July 12 Sun	22 kg/ha
July 13 Mon	Cont. application of Bti
July 19 Sun	22 kg/ha
July 23	22 kg/ha
July 28 Tues	22 kg/ha
August 2 Sun	22 kg/ha
August 6 Saturday	22 kg/ha
August 15 Saturday	22 kg/ha
August 22 Saturday	22 kg/ha
Methoprene	
August 29	11 kg/ha
September 19	11 kg/ha
October 10	11 kg/ha
October 31	11 kg/ha

3.3 Household- and Community-Level Control

The final component of the strategy was the household- and community-level control. Although the assessments determined that Wadi Dhuleil was the source of most of the breeding, it was also clear that household cesspools were a source of breeding and that their importance would increase when breeding in the Wadi was reduced. The only effective way to reach the general public was a focused public awareness campaign.

3.3.1 Strategy

The public awareness campaign was based on the classic elements of similar efforts: definition of the specific objectives, identification of the messages, determination of the audience for each message, identification of the communication channels, and development of an action plan to implement and monitor the campaign.
These were the specific objectives of the campaign:

- Reduce the household breeding sites, particularly cesspools
- Promote use of safe personal protection measures
- Ensure sustainable and effective control of breeding sites in Wadi Dhuleil

To achieve the first objective, it was neccessary to

- ensure cesspools were properly covered and eliminate the spaces between the access port and cover to prevent entry and exit of mosquitoes,
- screen over the vent pipe in the cesspools to prevent entry and exit of mosquitoes, and
- use methoprene/Bti in cesspools when applicable to control difficult situations.

These messages were aimed at heads of households, housewives, and school children.

To attain the second objective it was neccesary to

- use screens and bednets to keep mosquitoes out of the house whenever possible, and
- use household insecticides sparingly to protect the health of children.

These messages were aimed at heads of households, housewives, and school children.

To attain the last objective, it was neccessary to

- help keep the channel walls intact to prevent seepage and accumulation of standing water and
- place hoses of water pumps of farmers in the main stream to prevent formation of pools in which mosquitoes may breed.

These messages were aimed primarily at farmers.

The communication channels were as follows:

- Local women's committee meetings
- Municipality sanitarians
- Local chapter of the Jordanian Environmental Society (JES)
- Public meetings with farmers
- School health committees
- Teachers of local schools

3.3.2 Implementation

JES, a nongovernmental organization, was contracted to conduct the household and community pest control strategy. A five-member team met with the social scientist and the EHP entomologist to review the strategy, the activities, and the objectives of the campaign. It was agreed that the activities would include six localities: Al-Hashimiyya, As-Samra, Mazra'a, Um-Suleih-Gharesa, Sukhneh, and Duqqara.

The EHP entomologist prepared a fact sheet to be distributed to the inhabitants that would serve as an information source from which messages could be developed. The messages were developed by the social scientist, the JES team, the EHP entomologist, representatives from USAID/Jordan, MOH, and WAJ. All the proposed activities were discussed and agreed upon with the working committee.

The activities included the following:

- Development of printed materials
  - Stickers to be distributed to students, shopkeepers, and municipalities
  - A fact sheet to be distributed to teachers, students, shopkeepers, participants in discussion groups, and health centers
  - A wheel format containing information on mosquitoes, sand flies, and insecticides
  - Five billboards with messages similar to those found on the stickers to be placed in the five major localities in the area
  - Articles to be published in newspapers
- Development of discussion groups—These included key audiences in each locality, namely heads of households, housewives, students of both sexes, teachers, and farmers. Special training sessions were organized at the schools to enable teachers of science and environmental clubs to explain the messages to students of lower grades. These training sessions included an introduction to the EHP activity in the area, a discussion on biology and how to control pests using environmentally accepted means, and an introduction to the publication material prepared for the campaign.

The activities started on 28 September 1998. The number of attendees in the discussion groups ranged from 7 to 48. Officials of municipalities helped coordinate and facilitate the activities, which went well with few exceptions. Delays in communication between the schools and the Ministry of Education, which had to approve the activities and convey approval to the schools' principals, sometimes caused postponement of activities. In general, the campaign was well received by the community as demonstrated by the positive comments of teachers, housewives, and mayors of municipalities.

After evaluating the effect of the campaign in November 1998, EHP determined that a second campaign would help reach a higher percentage of the population. A second campaign was organized by the Jordanian social scientist and conducted from April to May 1999. Rather than contract with JES, EHP assembled its own team to conduct the campaign under the direction of the EHP social scientist. The messages were essentially the same, although more emphasis was given to working through community intermediaries such as the mayors, mukhtar, and the working committee in order to reach more people and to reinforce the role of the municipalitites in educating the public. As in the first campaign, the team used group discussions, laminated fact sheets, and billboards.

4 RESULTS

During October and November 1998, the entomological, social, and health reassessements were conducted to evaluate the success of the strategy. The entomological monitoring was ongoing throughout the entire period. This chapter summarizes the results achieved in each area. Appendix D provides a list of reports produced during this activity. In particular, the health and community assessment reports provide additional detail on the results achieved.

4.1 Entomological Results

4.1.1 Monitoring of control activities directed against immature stages of mosquitoes

The physical improvements conducted at parts of Wadi Dhuleil in early July led to the elimination of several mosquito breeding sites, including three at the monitoring sites (11, 34, and 54) (see Table 1). Similarly, the number of mosquitoes at immature stages were significantly reduced in many of the remaining sites from almost 50% in Sites 35, 51A, and 56, to more than 90% in Sites 8 and 30 (see Table 1). The use of VectoBac (Bti) at the Wadi commenced on 12 July 1998 and continued until 22 August 1998 (see Table 7). By the end of July, no breeding was detected in seven monitoring sites (Sites 8, 11, 30, 34, 35, 39, and 54) as a result of these activities. Appreciable reductions in the number of mosquitoes at immature stages were noted in four of the five remaining monitoring sites (Sites 51A, 56, 58, and 59) despite the fact that no physical improvements were carried out in those four sites. Thus, the reduction in the number of mosquitoes at immature stages there was attributed to the application of VectoBac. No control was noted in Site 61 because the presence of dense aquatic vegetation had led to inadequate treatment. By mid-August, the sites that had been physically improved experienced almost no breeding except for Site 35 where some seepage had occurred, providing the proper conditions for breeding. However, repeatedly treating the site with VectoBac led to the control of mosquitoes by the end of August. Minimal breeding was still noted at that time in sites that had received VectoBac treatment but no physical improvements (e.g., 51A, 58A, 59, and 61).

During September and October 1998, VectoBac was replaced by methoprene. Since this chemical does not kill immature stages but only prevents the emergence of normal adult mosquitoes, counting the number of larvae and pupae per dip at the monitoring sites would not help evaluate the breeding of mosquitoes. Procedures such as the laboratory rearing of third and fourth instar larvae collected from each site had to be followed. The results showed that approximately 50% of the larvae did not emerge into active adults. Since they would be continuously exposed to methoprene at these sites, it is expected that a lower percentage of larvae would emerge.

Of special note is the observed shift in species composition of mosquitoes that were still breeding in the sites examined in September. *Culex pipiens*, which feeds predominantly on humans and is the only mosquito species that attacks the inhabitants in Al-Hashimiyya, was replaced at several sites by *Culex sinaiticus*, which is a bird feeder. Thus, the burden on the inhabitants was also further reduced. By mid-October, mosquito breeding was almost eliminated from all the monitoring sites except Sites 35 and 51A. In the latter, more than 80% of mosquito larvae collected were *Culex sinaiticus*, and the emergence rate of *Culex pipiens* collected from Site 35 was 70%. The maximum mean temperature at Al-Hashimiyya during October was 28.6E C, a temperature still favorable for breeding.

4.1.2 Control of adult mosquitoes

In late June, before any control measure was taken, CDC light traps placed at the WWTP collected a significant number of adult mosquitoes (see Table 8). By the end of July, the numbers at the WWTP dropped by more than 85%. Similar reduction percentages were obtained during September and part of October.

Control activities carried out in Al-Hashimiyya during the following three weeks in July led to a 60% decrease in the number of trapped mosquitoes. However, an increase was noted in August in Site 1. Two factors that could have led to this increase are the presence of houses that were not connected to the sewerage system in that area (they still had cesspools), and the overflowing of sewage from a manhole along a major sewage pipe line leading to the accumulation of sewage water in one of the farms close to the trapping site. The drying of that pool of overflowing sewage and the application of methoprene and VectoBac to the cesspools in that area reduced the numbers obtained in August by 70% (see Table 8).

In Um-Suleih where all the houses use cesspools, the number of trapped adult mosquitoes did not point to a significant control during July and August despite the significant reduction in mosquito breeding in the Wadi. It was then realized that the main source of mosquitoes in Um-Suleih was the cesspools. This was confirmed when adult mosquitoes were seen flying out of cesspools when manholes were removed. As of September, and upon the recommendation of EHP consultants, workers from Um-Suleih municipality started adding a spoonful of methoprene or VectoBac to toilets in the houses of Um-Suleih in order to control mosquito breeding in the cesspools. The results were very satisfactory. At one site (Um-Suleih 2), more that 90% mosquito control was obtained compared with 60 to 70% in the other site (see Table 8).

At Sukhneh, despite the use of cesspools, mosquito breeding was relatively low before the initiation of control activities. Significant control of adult mosquitoes was achieved by September and October. It should be noted here that clearing of the Wadi along Sukhneh took place in September.

At Duqqara, where cesspools are also used, a 40 to 90% reduction in the number of trapped mosquitoes was noted during July, August, and September (see Table 8). The fluctuation in the results could be attributed to several factors. These include breeding of mosquitoes in cesspools, delay in clearing the Wadi along that area until September, and workers' relaxation in carrying out control activities.

Reductions in the number of trapped mosquitoes were noted at Mazra'a in July, August, and part of September (see Table 8), although an increase was seen in late September. The Wadi along Mazra'a was practically free from mosquito breeding as of late July, suggesting that the Wadi was not the source.

The number of adult mosquitoes collected in late October was very low at all sites. During this time, a weak depression passed through the area on the night of trapping and could have affected the outcome.

4.1.3 Human-landing rates of mosquitoes

The results of monitoring *Culex pipiens* mosquitoes feeding on humans in Al-Hashimiyya are presented in Table 2. During September and October, the number of mosquitoes coming to feed per person per hour had decreased approximately 90% compared to the numbers obtained in June before the initiation of the control activities. In Um-Suleih, more than 90% reductions were noted by mid-September and October after treating the cesspools with methoprene and VectoBac (see Table 3). In mid-September, nine

Table 8
Number and Sex of Adult *Culex pipiens* per Trap per Night Collected at Al-Hashimiyya Area

		DATE										
		6/8	6/19	6/28	7/13	7/31	8/14	8/28	9/10	9/25	10/9	10/29
WWTP (1)	♂	6	41	-	-	10	-	27	12	15	10	13
	♀	120	180	1220	510	155	218	251	149	240	385	112
WWTP * (2)	♂	14	61	-	8	20	-	-	26	5	24	1
	♀	10	7	250	20	30	20	9	20	20	8	9
Hashimiyya (1)	♂	-	-	-	-	-	10	40	-	12	-	-
	♀	1102	1620	2850	1110	1660	2190	2093	1085	738	595	41
Hashimiyya (2)	♂	1	12	-	5	2	4	2	1	-	2	-
	♀	48	80	100	35	67	44	13	18	34	28	5
Um-Suleih (1)	♂	-	-	-	-	-	10	80	15	-	-	-
	♀	880	1192	990	610	1860	2980	4075	1595	630	1290	13
Um-Suleih (2)	♂	-	25	-	-	-	-	250	15	-	-	-
	♀	420	745	240	410	380	830	1225	195	98	95	10
Sukhneh (1)	♂	-	20	8	-	-	-	21	5	-	-	-
	♀	200	142	70	185	200	114	155	236	81	80	15
Sukhneh (2)	♂	-	2*	-*	-*	-	-	-	2	-	-	2
	♀	30	-	40	2	27	40	21	28	21	8	12
Kora Beni Hashem (Duqqara)	♂	-	-	-	5	-	-	-	1	-	4	-
	♀	274	41	100	21	62	98	150	18	152	118	18
Masra'a	♂	ND	ND	2	ND	2	ND	2	-	-	4	-
	♀	ND	ND	34	ND	15	ND	15	6	53	28	9

* NJ trap
* WWTP : Wastewater Treatment Plant, N.J.; New Jersey Trap Town

mosquitoes came to bite per person per hour compared to as much as 141 mosquitoes landing on humans indoors and 112 outdoors in mid-June. In October, the corresponding numbers were one and nine per person per hour indoors and outdoors, respectively, despite the prevailing temperatures, which were favorable for mosquito breeding and survival.

4.1.4 Adult chironomids

Because chironomid larvae are usually buried in mud or in the algal masses growing in the effluent, regular monitoring is difficult and was limited to trapping of adults attracted to CDC miniature light traps or New Jersey traps.

The highest numbers of adult male and female chironomids collected per trap per night were recorded in June in Al-Hashimiyya, Um-Suleih, and Duqqara when no control activities were carried out (see Table 9). The results clearly show that the Wadi, from Al-Hashimiyya to Duqqara, is the major breeding site of the chironomids and not the treatment plant. This became evident when the physical improvements that took place in early July in the Wadi along Mazra'a, Al-Hashimiyya, and Um-Suleih led to a decrease in the numbers of trapped adults in the three areas. Thousands of larvae were observed in small pools formed when seepage areas were physically closed and during the drying of those pools. The water practically turned red due to the large number of larvae that were forced to concentrate in those pockets of water in the area.

Appreciable decreases in the number of adult chironomids were noted in September and October in all of the trapping sites except at the WWTP. In September, methoprene replaced Bti as the agent of chemical control, and physical improvements covered a large portion of the Wadi. No control activities were

Table 9
Number and Sex of Adult Chironomids per Trap per Night Collected at Al-Hashimiyya Area

		DATE										
		6/8	6/19	6/28	7/13	7/31	8/14	8/28	9/10	9/25	10/9	10/29
WWTP (1)	♂	31	48	110	62	35	63	138	23	23	20	81
	♀	22	20	120	18	16	29	14	62	15	20	55
WWTP * (2)	♂	42	92	70	30	20	13	43	20	10	91	50
	♀	42	22	100	20	15	7	-	28	15	1	23
Hashimiyya (1)	♂	540	310	160	70	80	168	13	13	12	20	3
	♀	104	90	220	50	40	200	14	22	11	15	2
Hashimiyya (2)	♂	10	6	-	10	-	2	-	-	3	-	1
	♀	-	8	30	-	-	-	-	-	-	-	3
Um-Suleih (1)	♂	331	490	100	70	145	150	-	15	12	35	8
	♀	140	200	110	50	115	78	-	55	18	55	2
Um-Suleih (2)	♂	160	4	30	85	61	92	60	26	-	8	4
	♀	80	6	40	25	30	78	10	55	14	12	3
Sukhneh (1)	♂	-	-	-	20	20	29	-	1	3	8	2
	♀	290	19	12	5	10	12	4	2	-	3	1
Sukhneh (2)	♂	60	21*	20*	4*	1	11	-	-	1	1	1
	♀	23	-	12	-	1	9	4	1	-	-	-
Kora Beni Hashem (Duqqara)	♂	310	20	30	20	8	12	20	-	5	-	7
	♀	390	12	52	8	1	10	20	3	11	-	4
Masra'a	♂	ND	ND	6	-	-	ND	-	-	2	33	4
	♀	ND	ND	-	-	-	ND	-	-	-	5	2

* WWTP : Wastewater Treatment Plant, N.J.; New Jersey Trap Town

carried out at the WWTP except for the partial clearing in mid-July of the Wadi about one km west of the effluent outlet (Site #1).

4.2 Community Reassessment

Community reassessment was conducted in October and November 1998 with the objective of assessing changes in the knowledge, attitudes, practices, and beliefs of the community as they relate to the pest problem in the Al-Hashimiyya area. The assessment involved the same three methods used for data collection in the May 1998 community assessment: individual interviews with key informants, a survey of 232 households, and 12 focus group discussions.

*Identification of insects.*The results showed that more people (20% instead of 11% in the first assessment) could distinguish mosquitoes from the nonbiting chironomids. Although most respondents (79%) recognized sand flies, some still confused their appearance and bites with those of mosquitoes.

Reduction in mosquitoes. The respondents reported that both mosquitoes and chironomids increased at the beginning of summer with the highest numbers in June and July (see Table 10). An appreciable decrease in the density of these insects was noted in August and September after clearing and maintenance of the Wadi and the application of biological agents to breeding sites took place. Many people reported that they could sleep without being bothered by mosquitoes and enjoyed sitting outdoors compared to previous years. Nevertheless, some still complained of mosquitoes, which was attributed to breeding in cesspools.

Table 10
Insect Density as Perceived by the Respondents

Insects	Months	Same as Before %	Decreased Notably %	Slightly Decreased %	Increased Impact %	n
Biting Insects	June	66.4	4.3	11.6	17.7	232
	July	53.0	14.7	22.0	10.3	232
	August	29.7	28.4	34.1	7.8	232
	September	26.3	35.8	31.0	6.9	232
Nonbiting Insects	June	62.5	8.3	16.7	12.5	48
	July	39.6	27.1	27.1	6.3	48
	August	20.8	39.6	35.4	4.2	48
	September	16.7	45.8	35.4	2.1	48
Sweikta	June	55.4	6.0	7.6	31.0	184
	July	53.8	8.7	12.5	25.0	184
	August	40.8	14.1	19.0	26.1	184
	September	38.0	19.0	17.9	25.0	184

Health impact. Although the number of bites decreased, other health problems such as skin allergies, respiratory problems, headaches, and unexplained fever did not decrease noticeably. It is important to note that the community did not distinguish between sand fly bites and mosquito bites. Table 11 shows community perception of the health impact.

Social impact. Many of the respondents (a total of 68%) reported that they could sit outside during the summer (as high as 78% in Hashimiyya). In addition, 66% reported that they slept well for the first time in many years.

Economic impact. Results indicated that people's spending on insecticides had decreased, especially during August and September. Many had acquired information about the side effects of insecticides from the various campaign's activities. The average family spent JD 6.78 per month in 1998 compared with JD 15 per month in previous years, a reduction of more than half. The reasons they spent less were a decrease in the number of mosquitoes and an awareness of the potential side effects of insecticides.

Use of household control measures. The second assessment revealed that 50% of respondents used fewer control measures than in the past. This was due to the decrease in the number of mosquitoes (according to 83%). Most respondents became much more aware of the hazards of using household insecticides, and as a result, 95% preferred using bednets. *Public awareness campaign*. Almost half of the respondents in the community had heard of the awareness campaign. The campaign's publications reached about one-third of the respondents, and one-quarter of those said that at least one of their family members had taken home campaign publications. Many people believed that the fact sheets were very clear and detailed, and some had memorized billboard messages.

The focus group discussions revealed great enthusiasm among students who had participated in the campaign group discussions. A high level of awareness of all the campaign messages was noted. Most of these students discussed the campaign's messages with their families or read the fact sheets to their parents. They referred to the importance and necessity of implementing the campaign messages, and many believed such campaigns should be done on a larger scale. The students suggested that more adults should be involved in the group

Table 11
Change in Health Problems as Reported by Respondents

	Al-Hashimiyya %	Sukhneh %	Um-Suleih-Gharesa %	As-Samra & Mazra'a %	Kori Beni Hashem %	Refinery %	Average %
Mosquito Bites							
Decreased notably	24.4	11.7	25.5	5.3	18.8	37.5	19.8
Slightly decreased	34.1	30.0	27.7	21.1	43.8	25.0	31.0
No decrease	41.5	58.3	46.8	73.7	37.5	37.5	49.1
Skin Sensitivity							
Decreased notably	14.6	-	10.5	-	10.0	50.0	9.4
Slightly decreased	37.5	23.5	26.3	40.0	30.0	50.0	33.0
No decrease	47.9	76.5	63.2	60.0	60.0		57.5
Difficulty in Breathing							
Decreased notably	20.0	9.1	20.0	-	-	-	15.8
Slightly decreased	17.5	27.3	13.3	33.3	40.0	50.0	21.1
No decrease	62.5	63.6	66.7	66.7	60.0	50.0	63.2
Getting Poisoned							
Decreased notably	22.2	-	-	-	-	-	15.4
Slightly decreased	22.2	-	-	-	-	-	15.4
No decrease	56.4	100	100	-	-	-	69.2
Headache							
Decreased notably	13.0	20.0	11.1	-	-	-	11.9
Slightly decreased	39.1	20.0	22.2	25.0	-	-	31.0
No decrease	47.8	60.0	66.7	75.0	100	-	57.0
Rise in temperature							
Decreased notably	9.5	11.1		-	-	-	7.5
Slightly decreased	42.9	11.1		33.3	-	-	30.0
No decrease	47.6	77.8		66.7	100	-	62.5
Sand Fly Bites							
Decreased notably	9.1	7.7	-	-	9.1	25.0	8.9
Slightly decreased	18.2	11.5	16.7	23.5	9.1	25.0	15.6
No decrease	72.7	72.5	83.3	76.5	81.8	50.0	72.5

discussions, and they believed that parents need more educational information.

Role of the community. The second assessment recorded a larger number of respondents (almost half) who believed they have a significant role to play in controlling the problem. The means of controlling the problem are becoming clearer. There is a much higher level of awareness of household measures such as screening the ventilation pipes, covering cesspools, and cleaning up animal manure. The other half of respondents said that their role is limited because they believe that the main cause of the problem is the WWTP, which is beyond their control.

4.3 Health Reassessment

The purpose of this activity was to assess the impact of the pest control activities on health.

4.3.1 Specific objectives

Specific objectives of the activity were as follows:

- Assess the opinion of people regarding the change in density of mosquitoes
- Assess the opinion of people regarding the change in density of sand flies
- Assess the change in pest-related health conditions after control measures have been undertaken in the area.

4.3.2 Approach

A total of 350 subjects attending Hashimiyya Housing Health Center during the period from 27 September to 10 October 1998 were included in this stage of the study. A trained

Table 12
Indices of Change among Hashimiyya Housing Health Center Attendees One Month After Control Measures Have Been Implemented

Indicator	Before	After	P
Insecticides:			
Spending > 10 JDs	51.9 %	27.2 %	0.000
Mean spending on insecticides (JDs)	11.2	6.7	0.000
Health conditions:			
Mosquito bites	57.2 %	15.2 %	0.000
Eczema	1.9 %	0.3 %	0.061
Urticaria	1.7 %	1.7 %	1.00
Nasal Allergy	11.2 %	6.3 %	0.010
Unexplained fever	7.8 %	2.6 %	0.001
Diarrhea	5.0 %	4.3 %	0.682

Note: None of the subjects reported anxiety, poisoning, or rat bites.

female interviewer personally interview each subject using a questionnaire designed to gather information regarding changes in density of pests and health conditions. A clinical examination focusing on potential health effects of exposure to pests and pesticides was also carried out for each participant.

4.3.3 Results

An evaluation of the control measures that were implemented in the area showed that they were effective. Evidence of mosquito bites dropped from over 57.2% to 15.2% (Table 12). Other conditions such as eczema and nasal allergy also showed a significant decline. Additional evidence of improvement was provided by inhabitants, more than two-thirds of whom reported a decline in mosquito density with only 19% reporting an increase.

5 SUSTAINABILITY

The sustainability of the pest control strategy depends on five main elements. The first is the physical improvements needed each year to prevent the development of seepage areas in which mosquitoes breed. The second is the regular treatment of Wadi Dhuleil with methoprene. The third is continued institutional and community support for the strategy. This includes the continued functioning of the working committee as well as WAJ and CCS. The fourth element is the proper sealing of the household cesspools with covers and covering the vent pipes with screens. The fifth element is regular entomological monitoring of mosquito and chironomid breeding. This chapter describes what will be needed in each area to ensure sustainability.

5.1 Physical Improvements

The most effective way to control mosquitoes and chironomids is by regularly shaping, clearing, and maintaining the Wadi Dhuleil. A single fast-flowing channel free from vegetation will eliminate almost all of mosquito breeding sites in the Wadi. Because WAJ and CCS conducted extensive shaping of the channel in 1998, shaping in 1999 and subsequent years should be quicker and less expensive. Most of the large boulders in the course of the Wadi in Al-Hashimiyya have already been removed. To maintain a good flow, the winter damage to the channel should be assessed each March, toward the end of the rainy season, to allow time for WAJ to make repairs before the breeding season. In addition, the entire length of the Wadi should be inspected every month from late March through October to determine if any interim maintenance is needed.

The annual estimate for Wadi maintenance is JD 10,000 to 20,000, depending on the extent of shaping required after the winter rainy season. WAJ must fund this maintenance and must ensure that funding is available so that Wadi maintenance can begin by April 1 each year. This will prevent the mosquito breeding from getting out of control and reduce the amount of methoprene needed to control breeding.

5.2 Treatment of Wadi with Methoprene

The second key to controlling mosquitoes and chironomids is the regular treatment of breeding sites with methoprene. The amount of methoprene to purchase depends on timely Wadi maintenance. If the Wadi is maintained each year beginning April 1, the amount of methoprene needed will be minimal. If, on the other hand, Wadi maintenance is not done, the supply will quickly become exhausted. WAJ currently gives JD 7,000 to 10,000 each year to CCS for spraying operations. Assuming timely Wadi maintenance, this should be enough on an annual basis. EHP currently has enough methoprene to last until 2001. More methoprene could not be purchased in advance because it has a two-year shelf life.

5.3 Institutional Roles and Responsibilities

The pest control strategy requires the participation of three major organizations: the working committee, WAJ, and CCS. The working committee's primary responsibility is to ensure that the control strategy is carried out each year. This entails making sure that WAJ, CCS, and the municipalities are each following through on their assigned responsibilities. The sustainability of the pest control effort depends on this.

EHP also produced a concise (17 page) *Community Guide for Mosquito Control* that summarizes the pest control strategy and provides the basic information needed by the working committee, CCS, and WAJ to implement the strategy.

5.3.1 Role of Working Committee

The responsibilities of the working committee are as follows:

- Meet in February to review what must be done for the upcoming breeding season
- Contact WAJ to ensure that the Wadi maintenance is on schedule
- Confirm that the workers from CCS and the municipalities are available and properly trained in the application of methoprene or Bti
- Ensure that the Wadi is inspected monthly to determine if any interim maintenance is needed
- Check with CCS to ensure that regular monitoring of larval breeding is being carried out and to find out what the results are
- Act as a resource to individual homeowners about ways to control mosquito breeding in cesspools
- Meet at least bimonthly during the mosquito season to review the results of the control measures

5.3.2 Role of Council of Common Services

The responsibilities of CCS are as follows:

- Store methoprene and Bti and tell the working committee when additional supplies must be purchased
- Train workers in the application of methoprene or Bti and ensure that the pesticide is applied correctly and in the right amounts
- Monitor larval breeding and adult emergence regularly
- Inspect the Wadi monthly to determine if any interim maintenance is needed

5.3.3 Role of Water Authority of Jordan

WAJ's responsibility is to carry out and pay for annual maintenance of Wadi Dhuleil.

5.4 Household Cesspools

The significant reduction in breeding in the Wadi has increased the importance of reducing breeding in the household cesspools. The two public campaigns raised awareness of the importance of ensuring that the cesspool covers are tightly fitted and that screens cover the vent pipes. However, follow-up is needed to ensure that the increased awareness results in a change in behaviors. The working committee has the ongoing responsibility to reinforce these messages and follow-up through existing channels. The second campaign worked through the existing channels more closely than in the first campaign, which should make follow up more likely to happen.

5.5 Entomological Monitoring

Monitoring of larval and pupal breeding

To monitor breeding of immature stages of mosquitoes and chironomids, different sites should be chosen along the water course. The sites should be checked weekly or biweekly for the presence of larvae and pupae. Since methoprene is a juvenile growth hormone regulator that does not kill larvae, pupae must be collected from each site and observed to determine the emergence rate, and consequently the success of the control measures.

Monitoring of adult mosquitoes

Two monitoring methods are recommended.

- *Light trapping.* Several types of traps can be used to collect adult mosquitoes. The most common is the CDC miniature light trap that uses carbon dioxide (dry ice) to improve the attraction efficiency. The traps are battery operated and are run from sunset to dawn. A six-volt motorcycle battery is usually used for each trap, as they can run almost 18 hours before needing to be recharged. The traps are installed at fixed sites away from other sources of light (e.g., street light).
- *Human-landing rates.* Trained human volunteers working in pairs, one indoors and the other outdoors, collect mosquitoes coming to bite their exposed legs. Electrical or manual aspirators are used for this purpose. The two workers should start collecting mosquitoes at

sunset and continue for the duration required (usually three hours), exchanging places every hour. A light torch is used to help the workers spot the mosquitoes. The insects collected every hour are placed in separate vials and labeled, and the vials are transported to the laboratory for counting and species identification.

5.6 Financial Support

Ongoing financial support will be needed in two areas: annual physical improvements to Wadi Dhuleil and the purchase of methoprene when current supplies run out.

6 CONCLUSIONS AND RECOMMENDATIONS

This chapter draws overall conclusions about the approach used and its potential for application elsewhere. In addition, the chapter highlights recommendations for ensuring the sustainability of the Hashimiyya Pest Control Strategy. Although the strategy is well defined and field tested, its long-term success depends on certain key actions being taken. These actions are summarized in this chapter.

6.1 Conclusions

- The approach to developing and implementing the pest control strategy was successful. The basic approach was to first carefully define the problem through a series of assessments and data collection activities, develop a strategy based on the information collected, implement and monitor the strategy, and evaluate its effectiveness. This approach worked very well and validated the importance of the baseline assessments.
- The development and implementation of a pest control strategy requires a multi-disciplinary approach. This activity involved medical entomologists, engineers, social scientists, epidemiologists, vector control specialists, facilitators, and institutional specialists. To develop a sustainable strategy, all aspects represented by these disciplines had to be taken into account. In addition, it is important to ensure that the effort is collaborative so that these inputs are coordinated and synergistic.
- The role of the community is critical to success. Perhaps the major accomplishment of this activity was engaging the community and helping them learn how to take responsibility for solving the problem. At the beginning of the activity, the message from the community was “we didn’t create this problem, so it’s not ours to solve.” During the course of the activity, this attitude changed as the community realized that they had an important role in solving the problem and in ensuring that WAJ and CCS carried out their respective roles. The working committee was the key vehicle for involving the community and enabling them to act as a full partner.
- The pest control strategy works. The combination of physical improvements to the Wadi, the use of a biological pesticide, and a household and community communications campaign resulted in a 98% reduction in mosquito breeding in the Wadi. Residents confirmed this in the social reassessment by reporting a significant improvement in the mosquito problem. Perhaps the best evidence was a 50% reduction in household expenditures on pest control measures. The health reaassment also confirmed this by showing a reduction in pest-related health problems.
- The public awareness campaign was critical to educating the community at large and fostering change in key behaviors. The two public campaigns conducted reached over half the target population and resulted in widespread dissemination of messages about the importance of controlling breeding in household cesspools, reducing the use of household insecticides, and ensuring that farmers do not intentionally create pools of stagnant water for their irrigation pumps.
- The sustainability of the approach is not yet assured because of two issues. One is that WAJ’s commitment to provide funding for timely maintenance of the Wadi is uncertain. Wadi maintenance did not occur in April 1999 as recommended because of the inability of WAJ and CCS to agree on the amount of funding needed. The second issue is future funding for methoprene when current supplies run out in June 2001. If, rather than purchasing insecticides for spraying, WAJ uses the funding to purchase methoprene, this will not be a problem. WAJ has expressed interest in this approach, but has not made any commitments.
- Future success will also depend on the ability of the working committee to continue functioning without any EHP involvement. While EHP believes the working committee is ready to function on its own, it is not certain this will occur.

6.2 Recommendations

The following recommendations represent the key actions needed to ensure the sustainability of the pest control strategy:

- WAJ needs to ensure the availability of funding each year for timely Wadi maintenance. If this does not happen every April, pooling will increase, vegetation will become denser, and mosquito breeding will increase. Wadi maintenance will become more expensive and additonal quanitities of methoprene will be required, thus increasing the cost of controlling breeding. If the pooling and vegetation density increase enough, even methoprene will not work.
- WAJ also needs to ensure the funding of the purchase of methoprene after June 2001. EHP estimates annual purchase of JD 5500-6500 of methoprene, provided timely Wadi maintenance happens. As already stated, using the funding previously reserved for spraying is an easy way to solve this problem.
- CCS should minimize its use of insecticide fogging and use the remaining money to pay for elements of the pest control strategy that are within its area of responsibility.
- CCS may need some modest support in monitoring the effectiveness of methoprene in the next few years. Because methoprene only inhibits the growth of mosquitoes, it is more difficult to determine if the larvicide is working. CCS has the primary responsibility for this monitoring, but may require some specialized assistance from the University of Jordan or the Hashemite University in the future.
- Although EHP involvement is over, USAID should continue to monitor the implementation of the strategy to see if any modest assistance is needed. If neccessary, any assistance could be provided locally.

This activity demonstrated two principal findings. First, it demonstrated an approach to vector control that has great applicability in Jordan and elsewhere. Second, it reinforced the central role of the community in solving similar problems. In Jordan in particular, with its long-standing reliance on central government to solve local problems, this activity showed how communities can be engaged and even take on the leading role in solving the problem. If the Hashimiyya community uses a similar model to begin solving other related problems, this activity will have been a great success.

APPENDIX A: Scope of Work

Development of Effective and Sustainable Pest Control Strategies in the Hashimiyya Area

GOJ-APPROVED VERSION OCTOBER 7, 1997

Background

In August and September 1997, a preliminary investigation of the nature and extent of the nuisance and public health significance of mosquitoes and other pests for communities surrounding the As-Samra wastewater treatment plant was conducted. The study was initiated at the request of the Water Authority of Jordan (WAJ), together with representatives of the local community.

The study was conducted under the auspices of USAID's Environmental Health Project (EHP), led by Dr. Pandu Wijeyaratne, an expert in the control of insects and other disease vectors**.** Dr. Wijeyaratne was assisted by representatives of the Hashimiyya community and by experts in vector control from the University of Jordan and from the Ministry of Health.

The study showed that insects (*Culex* mosquitoes and *Chironomus* flies, in particular), as well as rodents, are serious problems for these communities. The study report ("Initial Investigation of Insects and Other Pests in Communities Around the As-Samra Wastewater Treatment Plant," September 1997) contained a series of recommendations for controlling insects and other pests. This scope of work is for implementation of these recommendations.

The SOW consists of four principal tasks:

Task A: Establishment of a pest abatement working committee
Task B: Clearing, shaping, and maintenance of Wadi Dhuleil
Task C: Development of a detailed work plan for medium-term measures

- C.1: Baseline data collection
- C.2: Development of safe, effective, and sustainable pest control strategies
- C.3: Monitoring, training, and financial sustainability programs

Task D: Study of options for piping/channeling effluent in Wadi Dhuleil

Task A: Establishment of Pest Abatement Working Committee

EHP will assist the Hashimiyya municipality and the WAJ to jointly establish a pest abatement working committee. The essential purpose of the working committee will be to serve as the interface between government authorities (municipality and WAJ) and citizens in the development and implementation of a safe, effective, sustainable pest abatement program. The mandate of the working committee may be expanded at a later date, should the scope of the formal cooperation between WAJ and the local citizens expand beyond pest abatement.

The working committee will include representatives of the municipality, WAJ, the health sector, farmers, private sector, citizens, and others deemed necessary and appropriate by the municipality and by WAJ.

In establishing the working committee, EHP will employ the services of individuals or firms with significant practical experience in environmental mediation (i.e. in using consensus-based approaches to reaching agreement among divergent interests on environmental issues).

In establishing the working committee, the following matters will be detailed in a working committee charter, agreed to by all members:

- Interests to be represented, and who will represent them
- Mandate of the working committee (broad scope and specific issues and responsibilities)
- Operational procedures (meeting schedules, agenda setting, communications, ground rules and protocols, mechanisms for consulting with each member's constituency and for bringing their input back to the working committee, etc.)
- Establishment of issue-specific subcommittees, if appropriate
- Roles and responsibilities of each working committee member
- Other matters identified by the community and Government of Jordan (GOJ) representatives involved in the effort to form the committee

The working committee, of course, will be involved in Tasks B, C, and D.

Task B: Clearing, Shaping, and Maintenance of Wadi Dhuleil

The preliminary assessment of the pest problem concluded that mosquitoes and other insect pests could be significantly reduced if the stretches of Wadi Dhuleil located near communities were kept free of vegetation and were shaped to ensure rapid water flow and no stagnant water.

In response to this recommendation, WAJ has doubled its budget for clearing and shaping the Wadi. WAJ will have primary responsibility for keeping the Wadi clear, shaped, and free of stagnant water. It is anticipated that members of the community will play a role in ensuring that nothing is done to intentionally pond the water in the Wadi and in informing WAJ when maintenance work on the Wadi must be done.

There are several areas where further assistance is needed:

- The impact of Wadi clearing and maintenance on erosion and on sedimentation in King Talal Reservoir must be studied, and means to mitigate erosion problems developed, if necessary.
- An approach to, and schedule for, Wadi clearance and maintenance must be developed, taking into consideration factors such as the life cycles of pests of concern; the most effective (and safe) chemical herbicides; reasons for ponding (seepage, leakage, intentional ponding,etc.); and integration of Wadi maintenance efforts with other measures for pest control that will be undertaken in the longer term.

EHP will assist WAJ and the community to address these issues, and other issues pertaining to Wadi maintenance that might arise out of the working committee deliberations, or that might arise as Wadi maintenance is intensified in the coming months.

Task C: Development of Detailed Work Plan for Medium-Term Measures

The initial investigation identified a number of medium-term measures that will help mitigate the pest problem over time. Additional investigation is needed before implementation of these measures can begin. The investigation can be divided into three categories: baseline data collection; development of effective and sustainable implementation strategies; and monitoring and training.

EHP will assist WAJ and the community to conduct these investigations and develop the detailed implementation work plan. *As suggested in the initial investigation report, EHP will enlist the services of a U.S. county mosquito abatement district or consultant with the equivalent skills to assist with this task (and with other tasks in this SOW, as appropriate).*

C.1: Baseline Data Collection

Baseline data relevant to development and monitoring of control measures will be established. These data will include the following:

Area maps. EHP will assist the working committee to develop detailed area maps locating all sites of significance to insect and pest breeding and control (including a Wadi profile; pump out sites; planted sites and cropping pattern; livestock types and sites; potential vulnerable sites for ponding of Wadi water; home and small industry distribution patterns; etc.) The scale will be 1:20,000 or smaller. The area map will be GIS compatible, if feasible.

Entomological surveys. Conduct a detailed baseline survey of insect pests (adult insects and larvae) that could be related to As-Samra and/or its effluent. The survey should result in data of sufficient accuracy to serve as a standard of comparison for the effectiveness of control measures.

Rodent infestation survey. Conduct a comprehensive assessment of sewage-related rodents in the area, including mapping of habitat areas, with particular attention to any connection to the wastewater treatment plant. Determine the extent of infestation (or lack thereof) of rodents with the flea that can be a reservoir of bubonic plague.

Community assessments. Conduct additional focus groups combined with other sociological methods, to assess knowledge, attitudes, practices, and beliefs toward insects and other pests; coping strategies; attitudes and beliefs about the As-Samra wastewater treatment plant; opportunities for community participation in mitigation measures for insects and other pests; and related matters. The community assessments should result in data of sufficient accuracy to serve as a standard of comparison for the effectiveness of control measures and for changes in knowledge, attitudes, behavior, and beliefs over time, and should lead to the design of appropriate health education measures.

Heath status assessments. Conduct a detailed assessment of the health status of the community as related to insects and other pests, including serological surveys if appropriate.

Insecticide use and effectiveness assessment. Conduct a detailed assessment of patterns of insecticide use in the home and by the municipality. Determine the resistance of adult insects to the insecticides commonly used and to other insecticides that might be more effective. Determine the larvicidal efficacy of cost-effective, environmentally safe larvicides.

C.2: Develop Effective and Sustainable Pest Control Strategies

EHP will assist WAJ, the municipality, and the Council of Common Services to develop an effective and sustainable pest control strategy. The components of the strategy will be determined collaboratively with the working committee. The following approaches are expected to be considered in developing the strategies:

Larvicidal program. Test biological larvicidicing for effectiveness in controlling the target Culex mosquitoes and chironomid flies (*Bacillus thuringensis* and *Bacillus sphaeircus* particularly). Slow or sustained release bricks or granule formulations should be tested for use both in the treatment plant and in the Wadi. If this approach is effective, develop a comprehensive strategy for its use.

Chemical insecticiding. Considering the results of the insect resistance and safety investigations conducted during baseline studies, develop a strategy for selective, judicious use of chemical insecticides, both by the municipality and by homeowners. The strategy should involve minimal use of chemical insecticides for maximum effect (i.e. targeted, carefully planned use to meet a specific need that cannot be met by other approaches).

Livestock relocation. Investigate the pros and cons of locating livestock near the Wadi, to serve as a barrier between the mosquito breeding sites and the community (mosquitoes feed on the closest target; if livestock are close to the Wadi, mosquitoes may feed there, rather than moving into the community). Issues of increased erosion caused by livestock grazing close to the Wadi must be carefully considered.

Rodent control. If baseline study of the rodent infestation determines that As-Samra impacts the presence of rodents in the community, develop and implement a strategy for control of sewer rats, working together with the Amman Governorate rodent control department.

Bednets. Explore the possibility of extensive use of bednets (chemically treated or untreated) to provide immediate relief (for the next couple of years) pending the insect problem being brought fully under control.

C.3: Monitoring, Training, and Financial Sustainability Programs

EHP will assist WAJ and the working committee to develop means to monitor the effectiveness of the insect and pest control measures applied and to measure the overall impact on the community.

EHP will also assist in the development of training programs so that the pest control programs will continue to be employed effectively after USAID assistance is no longer available for this activity. Similarly, EHP will assist WAJ and the community to secure an ongoing source of funds needed to carry out these programs effectively after USAID assistance is no longer available.

Task D: Study Options for Piping/Channeling Effluent in Wadi Dhuleil

EHP will assist WAJ and the community to thoroughly investigate the risks and benefits of conveying As-Samra effluent via a pipeline or constructed channel. The analysis will include considerations of the following:

- Effectiveness and reliability of insect control measures developed under Tasks A through C above
- Water quality improvements that would or would not be obtained if the water is piped or channeled in concrete
- Impact of implementing additional treatment measures at As-Samra (increased aeration, installation of mechanical plant) on the need for piping/concrete channeling
- Public health and groundwater protection issues related to piping/concrete channeling
- Impacts on farmers of piping/channeling
- Estimate of construction costs and operations and maintenance costs
- Related matters

Personnel

The activity will require personnel skilled in the areas of entomology, social science, public health, engineering, collaborative problem solving, and training and organizational development. All personnel will have significant hands-on practical experience in their respective fields. The contractor will use a joint U.S. and Jordanian consultant team.

Deliverables

Deliverable #1: Detailed Work Plan. Deliverable #1 is a detailed work plan for implementation of this activity, including the tasks and subtasks, schedule for each task, personnel involved, and budget.

Deliverable #2: Report on Task A. Deliverable #2 is a detailed report on the pest abatement working committee, including how it was established, how representatives were chosen, what the various interests are

and who will represent them, what the committee mandate and operational procedures are, and other relevant matters.

Deliverable #3: Report on Task B. Deliverable #3 is a report on the clearing, shaping, and maintenance of Wadi Dhuleil, including the recommended improvements, environmental considerations and documentation required, schedule and procedures for clearing and maintaining the Wadi, mitigation measures needed to ensure safe use of any herbicides, and impact of Wadi clearing and maintenance on erosion and sedimentation in King Talal Reservoir.

Deliverable #4: Report on Task C. Deliverable #4 is a report on the development of a detailed work plan for medium-term measures. It should report on the findings and recommendations for the following:

Subtask C.1. Baseline data collection including area maps; baseline survey of insect pests related to As-Samra and its effluent; results of rodent infestation survey; results of community assessment and health status assessment; and the results of the insecticide use and effectiveness assessment. The report should also describe the implementation process and personnel involved.

Subtask C.2. Pest control strategy defining the pest management strategy, roles and responsibilities for implementation, personnel needed, schedule, and expected cost.

Subtask C.3. Description of the monitoring systems to measure the effectiveness of the insect/pest control measures including the impact on the community; training programs developed; and plan for future program funding including source of funds.

Deliverable #5: Report on Task D Deliverable #5 is a report on the risks and benefits of conveying As-Samra effluent via a pipeline or constructed channel.

Deliverable #6: Summary report Deliverable #6 is a 10- to 15-page report that summarizes the findings of tasks A, B, C, and D. This one report will capture the main findings and elements of the pest control program so that the information is readily accessible to Jordanian decision makers and other USAID staff who do not have the time to read all the detailed reports.

Timeline

This activity will be implemented during 1998. Completion date is 31 December 1998.

APPENDIX B: EHP Team

Jordanian Consultants

Team Leader and Medical Entomologist—Dr. Elias Saliba
Social Scientist—Amal Barhoum
Epidemiologist—Dr. Anwar Batieha
Facilitator—Narmine Muna
Social Scientist Methodologist—Dr. Mohamed Barhoum
Rodent Control Specialist—Farhan Hamarsheh
Public Awareness Campaign—Jordan Environmental Society
GIS Mapping—Infograph

U.S. Consultants

Facilitator—Kathy Alison
Vector Control Specialist—Matthew Yates
Vector Control Specialist—Dr. Michael Carroll
EHP Technical Manager—Dr. Pandu Wijeyaratne
EHP Project Manager—Fred Rosensweig
EHP Assistant Activity Manager—David Fernandes

APPENDIX C: Sampling Stations for Mosquito and Chironomid Larvae and Pupae

Dr. Mike Carroll, Dr. Elias Saliba, and Matthew Yates

SAMPLING STATION NO.	SITE INFORMATION
1	Inside the chlorine contact basin at the As-Samra Plant, prior to the discharge weir at the As-Samra Treatment Plant. Site is marked with orange paint, # "1."
2	S.W. corner of maturation pond M2-2. This it the first pond north of the Chlorine Contact Basin. From site # 1 drive uphill toward this pond and turn left on the levy. Sample near the rock marked # 2.
3	Continue going the same direction from site # 2 along the levy. Site # 3 is at the first comer, in maturation pond M2-3.
4	Continue along the levy and take a forced right turn, then continue along the levy for about 125 m to an abandoned pump house, marked "4." Sample seepage area near the pump house.
5	Near abandoned pump house, 100 m from site # 4. Follow the seepage down the hill. Go across the fence and continue downhill for about 100 m and sample rock pools near the rock marked # 5. Mosquito larvae were present on April 11,1998.
5 A	Continue along levy from site # 4 to maturation pond M1-4. Sample near the location marked # 5 A. Chironomids were present on April 15.
	From sampling station # 5 A leave the WWTP and go through Hashimiyya, past the municipality building, and take a right. Go straight until you come to a sign advertising Yougart-of Masoud (or Hammodeh) and then turn right and go straight until you come to the asphalt road crossing, 4 m wide, which Jonathan French lists as his station # 3. Take the dirt road on the south side of the channel and follow it back upstream to the point where Wadi Muttalalleg joins the channel (Jonathan French's station # 2). Our sampling station # 6 is near this location.
6	Mouth of Wadi Muttalalleg. Sample water backing up into the wadi from the channel along the south side.
7	This sampling site is on the south side of the stream, downstream of site # 6. The sampling station is located near where a small ravine (wadi?) intersects the channel and about 50 m upstream from the end of the fence. There is a culvert about 1 ½ m in diameter under the road at this location.
8	This sampling station is downstream from # 7. It is 75 m upstream from the asphalt road crossing (Jonathan French's station # 3) and is located on the north side of the channel.

9	This sampling station is on the N.W. side of the asphalt road (Jonathan French's # 3 station). Mosquito larvae were present on April 18, 1998.
10	This site is downstream from # 9. It is 100 m upstream of the 6 box culvert (French's # 5 station) and is on the south side of the channel.
11	This sampling station is 25 m upstream of the 6 box culvert and is on the south side of the channel.
12	Across the channel from site # 10. Twenty five (25) m upstream of 6 box culvert (Jonathan French's Station # 5).
12 A	50 m upstream of site # 12. Sample 12 A only if # 12 is dry.
13	50 m downstream of 6 box culvert on N. side of wadi.
14	30 m upstream of # 13 on the north side of the channel.

The sampling time for sites 15-25 will be approximately 1¼ hours.

15	75 m downstream of # 14 on the north side of the channel. Four concrete columns approximately 4 m high are near the site.
16	80 m E of # 15 on the same side of the channel.
17	170 m E of # 16 on the same side of the channel.
18	Approximately 30 m downstream from # 17 on the same side of the channel.
19	Approximately 40 m downstream from # 18 on the same side of the channel.
20	Approximately 75 m downstream of site # 19 on the same side of the channel.
21	Approximately 150 m downstream from site # 20 on the same side of the channel. Sample water in rock pools.
22	Approximately 30 m downstream from # 21 on the same side of the channel.
23	Approximately 40 m downstream from # 22 on the same side of the channel.
24	Approximately 80 m downstream of # 23 on the same side of the channel. Sample water in stagnant pool.
25	Approximately 40 m downstream of # 24 on the same side of the channel. Sample stagnant pools (lots of algae at time of site selection).
26	Approximately 80 m downstream from # 25 on the same side of the channel. Sample stagnant pools (lots of algae at time of site selection). The site is between a pump house (or storage building) and a poultry farm. The site is approximately 100 m upstream from the bridge (Jonathan French's station # 6).

27	The site is a stagnant water pool at northwest side of the bridge (Jonathan French's station # 6).
28	This sampling site is on the north side of channel approximately 50 m downstream of a pump house and 250 m downstream from site # 27. It is near a block wall with large cactus growing on the wall.
29	North side of the wadi, downstream from # 28. This site is across the wadi from a house with olive trees and cedar trees in front of the house.
30	The site is on the north side of the wadi, approximately 75 m downstream from site # 29. It is across the wadi from a dairy barn and an olive orchard.
31	On the north side of the wadi approximately 20 m downstream from # 30, across the wadi from the southwestern edge of an olive orchard.
32	Approximately 30 m downstream from # 31 on the north side of the wadi. There is an abandoned barn prickly pear cactus and a grape arbor near this site. There are three pumps and irrigation pipes in the channel on the opposite side of the wadi.
33	A stagnant pool (with algae at time of selection) on the north side of wadi about 180 m downstream from site # 32. The site is near a pine tree plantation and a large irrigation pump.
34	This sampling site is near Jonathan French's station # 7, at Zarqa-Irbid Hwy. Bridge. Sample the stagnant pools on the north side of the channel. Chironomids were present at the time of site selection.
35	This site is opposite site # 27, at Jonathan French's station # 6. It is on the south side of the wadi. Sample the rock pools near the southwest corner of the bridge (one-box culvert carrying one-lane road). This site was positive for Culiseta and Chironomid larvae and mosquito pupae on Thursday, April 9, 1998. It was, perhaps, one of the first sites along the wadi to produce mosquitoes in 1998, as they were in later stages of development than at other locations along the wadi. Dr. Saliba's students had collected larvae from this location earlier in the month.
35A	This site is upstream from site # 35 and across the bridge. It is about 5 m upstream from the bridge on the south side of the wadi.
36	Sample rock pools a few meters downstream from site # 35, on the south side of the channel, near an olive orchard and livestock pens.
37	A stagnant pool a few meters downstream from site # 36. Located on the south side of the channel, opposite a building on north side of the wadi, which has prickly pear cacti on a stone wall, pigeons in an outbuilding, and a large dog.
38	Still pool downstream from site # 37, on the south side of channel (number near water). The site is opposite a poultry house on the north side. The site is long and narrow. Sample at 4 locations along its length.

39 Downstream from site # 038. A series rock pools on the south side of the wadi, approximately 275 m upstream from Jonathan French's station # 7. The site is near the edge of an olive orchard.

40 A flat open area downstream from site # 39, on the south side of the channel. It is near a pump house and near the edge of an olive orchard.

41 A still water area on the south side of the channel upstream from the Zarqa-Irbid bridge (Jonathan French's station # 7).

Sites 42-50 will require about 1 hr sampling time.

42 Stagnant water pools on north side of the channel. The pools are about 50 m downstream from the Zarqa-Irbid Bridge (Jonathan French's station # 7).

43 This site is on the south side of channel facing the pump and near a block building. It is downstream of the Zarqa-Irbid bridge.

44 Rock pools on the north side of the channel approximately 100 m downstream from site # 43--chironomids and mosquito larvae present at time of sampling.

45 Rock pools on north side of channel 150 m downstream from site # 44.

46 Pools on north side of channel where water is still, an area approximately 75 m in length. Approximately 90 m downstream from # 45 and near a barley field. It is across the wadi from a water pump.

47 Rock pools on the north side of channel approximately 50 m downstream from site # 46. Mosquito and chironomid larvae were present in the site at the time of site selection.

48 An 80 m stretch of rock pools on the north side of the channel about 20 m downstream from site # 47. Larvae present at time of selection-probably Culex or Culiseta.

49 A large area of slow, stagnant water on the north side of the channel about 20 m downstream from a pump and prickly pear cactus plants.

After sampling site # 49, walk back to the road and drive to site # 50.

50 A still water area on the north side of the channel at the northeast comer of the bridge (Jonathan French's station # 8). Chironomids were present at time of site selection.

51 A 100 m long still pool along the south side of the channel upstream from the bridge (Jonathan French's station #8). To get to this site, drive west along the dirt road on the south side of the wadi until you reach the edge of the stand of prickly pear cactus. Then walk down the fence line toward the wadi until you see a rock with the # 51 on it. Cross under the fence and continue down to the wadi. Sample the pool, which is about 25 m downstream from the marker. Return to vehicle and drive back to bridge.

52	Several still, stagnant pools along the north side of the channel, downstream from the bridge (Jonathan French's station # 8).
53	Still rock pools along the north side of the channel. There are five poultry houses across the wadi from this site. After checking sites 52 and 53, walk back to bridge and take vehicle to site # 54.
54	A stagnant pool on the south side of the channel east of the bridge with the 6 box culvert (Jonathan French's station # 9). This site is approximately 60 meters upstream from the bridge. Walking to the site is very difficult and the technicians should take a shovel to carve out steps along the embankment to avoid falling.
*****	Mosquito larvae were observed in a barrel in the water at the southeast corner of the bridge (Jonathan French's station # 9).
55	A stagnant pool on the south side of the channel approximately 150 meters downstream from the bridge. The slope of the south wall of the wadi is very severe and the wall of the wadi is very high downstream from the bridge. Therefore, the inspector must walk downstream from the bridge, past the Paper Plant waste ponds, to a point where the wall of the wadi is less severe, walk down to the channel and back upstream to reach this site. The sampling station will be several meters upstream from the place he/she walks down the embankment to the channel. After sampling this site, walk back to the vehicle and drive to site # 56.
56	Rock pools from irrigation water from greenhouses. To reach this site, drive downstream from the bridge (Jonathan French's station # 9) along the dirt road on the south side of the wadi. Stop downstream from the greenhouses, which are upstream from siphon line # 2 (Jonathan. French's station # 11). Walk down the embankment and then back upstream to the site. The sampling site is approximately 50 meters upstream of the point where the Wadi Saeda (Jonathan French's station # 10) joins the Wadi Dhuleil. After sampling the site, return to the vehicle and drive to site # 57.
57	Seepage, 500 m upstream of siphon pump. Site is visible from the road. Park vehicle upstream from confluence of Wadi Saeda with Wadi Dhuleil near bridge and walk to site. Return to vehicle and drive to site # 58.
58	Rock pools and stagnant water upstream of black plastic pipe (near Jonathan French's station # 13). Park vehicle on right side of road downstream of three houses. Road drops off sharply at this point and a 4-wheel drive vehicle would be necessary to drive to the site. Walk down to the site, which is near siphon # 1. Sample the rock pools near the rock marked # 58.
59	Several slow, stagnant pools up to 100 m upstream of the Hasiya Road bridge (Jonathan French's station # 13).
60	Stagnant pools 20 m downstream from site # 59. Chironomids were present at the time site was selected.
61	The end of the study area. The water was clear and fast flowing. Those locations where still water was present had fish, frogs, turtles, and tadpoles present and no emergent vegetation. The combination of other aquatic life and the absence of

emergent vegetation make it very unlikely that any significant mosquito or chironomid breeding is occurring beyond this point. This site should be checked as it could become a breeding site during the summer when climatic conditions act to change the quality of the water in the wadi.

OTHER SAMPLING STATIONS

Jordan Refining Company

- Sample the water retention tank near Wadi Saedeh.
- Sample the discharge water used in irrigation.
- Sample the retention pond inside the gate at the top of the hill.
- Sample the maturation ponds at the residential wastewater treatment facility.

As-Samra pumping stations

- Sample downstream of the pumping station at Hashimiyya.
- Sample downstream of the pumping station at As-Sukhna.

APPENDIX D: List of Reports Produced

Following is a list of main reports produced under the Pest Control Activity.

Alison, Kathy and Narmine Muna. February 1998. *Development of effective and sustainable pest control strategies in the Al-Hashimiyya Area—Trip report summary* (contains working committee by-laws).

Al-Imran. August 1998. *Task C—Medium-term pest control measures: Community assesment, interim report, round 1.*

Al-Imran. February 1999. *Final report (community assessment).*

Batieha, Anwar. December 1998. *Health assessment of neighboring residen*ts.

Carroll, Michael, Elias Saliba, and Matthew Yates. April 1998. *Jordan pest control project, baseline data collection.* Trip Report.

EHP Team. March 1999. *Community guide for mosquito control.*