PMI/MOZAMBIQUE
INDOOR RESIDUAL SPRAYING
SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT
2015-2020

NATION WIDE
PYRETHROIDs, CARBAMATES,
ORGANOPHOSPHATES, DDT
AND CHLORFENAPYR

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MAY 2015

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INDOOR RESIDUAL SPRAYING
SUPPLEMENTAL
ENVIRONMENTAL
ASSESSMENT, 2015-2020

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PYRETHROIDS, CARBAMATES,
ORGANOPHOSPHATES, DDT
AND CHLORFENAPYR

OCTOBER 2015

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<tr>
<td>ACTs</td>
<td>Artemisinin-based combination therapies</td>
</tr>
<tr>
<td>ADS</td>
<td>Automated Directives System</td>
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<tr>
<td>AIRS</td>
<td>Africa Indoor Residual Spraying</td>
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<tr>
<td>ANC</td>
<td>Antenatal clinic</td>
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<tr>
<td>BCC</td>
<td>Behavior Change Communication</td>
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<tr>
<td>BEO</td>
<td>Bureau Environmental Officer</td>
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<tr>
<td>BMP</td>
<td>Best Management Practices</td>
</tr>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>CFR</td>
<td>U.S. Code of Federal Regulations</td>
</tr>
<tr>
<td>CS</td>
<td>capsule suspension</td>
</tr>
<tr>
<td>DDT</td>
<td>dichloro-diphenyl-trichloroethane</td>
</tr>
<tr>
<td>DFID</td>
<td>Department for International Development</td>
</tr>
<tr>
<td>DHO</td>
<td>District Health Office</td>
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<tr>
<td>DHS</td>
<td>Demographic and Health Survey</td>
</tr>
<tr>
<td>DIS</td>
<td>Department of Information</td>
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<tr>
<td>DNSP</td>
<td>National Directorate of Public Health</td>
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<tr>
<td>DPMA</td>
<td>Provincial Department of Environment</td>
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<tr>
<td>DPROS</td>
<td>Health Promotion Department</td>
</tr>
<tr>
<td>DPS</td>
<td>Provincial Department of Health</td>
</tr>
<tr>
<td>EC</td>
<td>emulsifiable concentrate</td>
</tr>
<tr>
<td>EIA</td>
<td>Environment Impact Assessment</td>
</tr>
<tr>
<td>EMMP</td>
<td>Environmental Mitigation and Monitoring Plan</td>
</tr>
<tr>
<td>EOSR</td>
<td>End-of-spray Report</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FY</td>
<td>Fiscal Year</td>
</tr>
<tr>
<td>GF</td>
<td>Global Fund</td>
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<tr>
<td>GFATM</td>
<td>Global Fund for AIDS, Malaria and Tuberculosis</td>
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<tr>
<td>GHI</td>
<td>Global Health Initiative</td>
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<tr>
<td>GoM</td>
<td>Government of Mozambique</td>
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<tr>
<td>HIV/AIDS</td>
<td>Human immunodeficiency virus/acquired immune deficiency syndrome</td>
</tr>
<tr>
<td>IEC</td>
<td>Information, Education, and Communication</td>
</tr>
<tr>
<td>IMVCS</td>
<td>Integrated Malaria Vector Control Strategy</td>
</tr>
<tr>
<td>INNOQ</td>
<td>National Institute of Standardization and Quality</td>
</tr>
<tr>
<td>INS</td>
<td>National Institute of Health</td>
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<tr>
<td>IP</td>
<td>Implementing Partner</td>
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<td>IPM</td>
<td>Integrated Pest Management</td>
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<tr>
<td>IPT</td>
<td>Intermittent preventive treatment of pregnant women</td>
</tr>
<tr>
<td>IRS</td>
<td>Indoor Residual Spraying</td>
</tr>
<tr>
<td>ITN</td>
<td>insecticide-treated net</td>
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<tr>
<td>IVM</td>
<td>Integrated Vector Management</td>
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<tr>
<td>LLIN</td>
<td>long-lasting insecticidal net</td>
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<tr>
<td>LSDI</td>
<td>Lubombo Spatial Development Initiative</td>
</tr>
<tr>
<td>MITADER</td>
<td>Ministry of Land, Environment and Rural Development</td>
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<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
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<tr>
<td>MCH</td>
<td>Maternal and Child Health</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
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<tr>
<td>MICOA</td>
<td>Ministry for Coordination of Environmental Affairs</td>
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<td>MIP</td>
<td>Malaria in pregnancy</td>
</tr>
<tr>
<td>MINAGRI</td>
<td>Ministry of Agriculture and Risk</td>
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<tr>
<td>MIS</td>
<td>Malaria Indicator Survey</td>
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<tr>
<td>MISAU/MOH</td>
<td>Ministry of Health</td>
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<tr>
<td>MOP</td>
<td>PMI’s Malaria Operational Plan</td>
</tr>
<tr>
<td>MSDS</td>
<td>material safety data sheet</td>
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<tr>
<td>NEMP</td>
<td>National Environmental Management Program</td>
</tr>
<tr>
<td>NGO</td>
<td>nongovernmental organization</td>
</tr>
<tr>
<td>NMCC</td>
<td>National Malaria Control Commission</td>
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<tr>
<td>NMCP</td>
<td>National Malaria Control Program</td>
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<tr>
<td>NHS</td>
<td>National Health System</td>
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<tr>
<td>OPs</td>
<td>organophosphates</td>
</tr>
<tr>
<td>PCD</td>
<td>Disease Prevention Control</td>
</tr>
<tr>
<td>PEA</td>
<td>Programmatic Environmental Assessment</td>
</tr>
<tr>
<td>PEDOM</td>
<td>Pulverizacao Extra Domiciliaria (extra household spraying)</td>
</tr>
<tr>
<td>PEPFAR</td>
<td>Presidents Emergency Program for AIDS Relief</td>
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<tr>
<td>PMI</td>
<td>President’s Malaria Initiative</td>
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<tr>
<td>PMU</td>
<td>Program Management Unit</td>
</tr>
<tr>
<td>POP</td>
<td>persistent organic pollutant</td>
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<tr>
<td>PPE</td>
<td>personal protective equipment</td>
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<td>PSMS</td>
<td>Pesticides Stocks Management</td>
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<td>PSI</td>
<td>Population Services International</td>
</tr>
<tr>
<td>RESP</td>
<td>Repartição de Educação para a Saúde Publica, now called DEPROZ: Department of Health Promotion</td>
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<tr>
<td>RBM</td>
<td>Roll Back Malaria</td>
</tr>
<tr>
<td>RDT</td>
<td>rapid diagnostic tests</td>
</tr>
<tr>
<td>SDSMA/DDS</td>
<td>District Services for Health, Women and Social Welfare</td>
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<td>SEA</td>
<td>Supplemental Environmental Assessment</td>
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<tr>
<td>SOP</td>
<td>Spray Operator</td>
</tr>
<tr>
<td>SP</td>
<td>Sulfadoxine pyrimethamine</td>
</tr>
<tr>
<td>TOT</td>
<td>Training of Trainers</td>
</tr>
<tr>
<td>UNEP</td>
<td>United Nations Environment Program</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<tr>
<td>USAID</td>
<td>U.S. Agency for International Development</td>
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<td>USEPA</td>
<td>U.S. Environmental Protection Agency</td>
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<td>USG</td>
<td>U.S. Government</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WHOPES</td>
<td>WHO Pesticide Evaluation Scheme</td>
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The authors of this report gratefully acknowledge the support given to this activity by the staff of Abt Associates who are involved in the project in Mozambique. Specific acknowledgement is given to Cathy Clarence, Duartina Francisco, Faida Cardoso and Luis Machate for their guidance and assistance.
I. Summary of Findings

1.1 Malaria Burden in Mozambique

Malaria is endemic throughout Mozambique, and its entire estimated population of 24 million people is at risk of malaria. Most of the country has year-round malaria transmission with a seasonal peak during the rainy season, from December to April. In addition, Mozambique is prone to natural disasters such as drought, cyclones, and floods, which may have contributed to increases in malaria transmission in recent years, particularly in low-lying coastal areas and along major rivers.

Malaria is considered the most important public health problem in Mozambique and accounts for 29% of all deaths, followed closely by AIDS at 27%. Among children less than five years old, malaria accounts for 42% of the deaths, followed by AIDS at 13%. *Plasmodium falciparum* accounts for 90% of all malaria infections, with *P. malariae* and *P. ovale* responsible for about 9% and 1%, respectively. The major vectors in Mozambique are *Anopheles gambiae* s.s., *An. arabiensis*, and *An. funestus* s.s. Of the major subspecies of the *An. gambiae* complex, *An. arabiensis* is more prevalent in the south and *An. gambiae* in the north.

The Mozambique Ministry of Health (MISAU/MOH) has been supporting limited Indoor Residual Spraying (IRS) operations in peri-urban and urban areas throughout Mozambique since the 1960’s eradication era. The MISAU/MOH-led IRS program in Zambezia Province where malaria prevalence is the highest began in 2005 in three districts (Quelimane, Namacurra, and Nicoadala) and used DDT. It was then expanded into parts of three additional districts (Morrumbala, Mocuba, and Milange) in 2006. In 2007, the National Malaria Control Program (NMCP) and provincial health authorities requested PMI to support the spraying operations in those six districts. After the first President’s Malaria Initiative (PMI) supported spray operation in 2007, the NMCP and PMI agreed to consolidate the IRS operations focusing on the more densely populated areas, as opposed to blanket spraying of the entire population.

Indoor residual spraying remains a high priority vector control intervention for MISAU/MOH in Mozambique with the objective to ensure that 100% of the population has access to at least one method of malaria prevention (IRS or LLINs). The Malaria Acceleration Plan 2014–2016, which is a multi-year operational plan of the malaria control strategy, and Mozambique’s Global Fund NFM concept note call for a scale-up of LLIN distribution and a more targeted approach for IRS. As a result, districts that were formerly targeted to just receive IRS are now also slated to receive universal LLIN coverage. Although an integrated vector control strategy was drafted in 2013, it did not take into account universal coverage of LLINs in former “IRS districts.” Therefore, within the next year, with PMI support, the NMCP will be working to draft a new malaria vector control strategy.

1.2 PMI Support in Mozambique

In 2007 Mozambique was selected as one of the four countries to receive funding during the second year of the President’s Malaria Initiative. The Mozambique PMI IRS program focused on supporting the NMCP IRS program in up to six districts in Zambézia Province.

Presently, PMI support to Mozambique is in line with the GoM’s 2012-2016 National Malaria Control Strategy. Funding is targeted to fill gaps in activities not already supported by the NMCP, Global Fund,
or other donors. PMI support is also targeted to translating best practices in malaria prevention and control to areas and activities currently supported by other funding agencies.

Supported activities continue to focus on achieving and maintaining high coverage of LLINs, particularly among the vulnerable populations of pregnant women and children under five, targeting IRS in Zambézia to complement national universal coverage campaigns, providing sulfadoxine pyrimethamine (SP) and support for intermittent preventive treatment of pregnant women (IPTp) scale-up, and improving case management, along with supportive activities such as Behavior Change Communication (BCC), strengthening supply chain management, and monitoring and evaluation (M&E).

PMI plans to decentralize its support to the provincial and district level. The objective of this approach is to improve implementation of malaria-related activities through the facilitation of supervision, distribution of commodities, and M&E. PMI will establish a provincial-level platform for BCC, Malaria in pregnancy (MIP) interventions, M&E, and case management in four provinces (Nampula, Cabo Delgado, Zambézia, and Tete). These provinces have been selected because of their high burden of malaria and the presence of strong local partners. In provinces where the USG has existing partners, efforts will be made to use these existing mechanisms, thereby following the GHI mandate and avoiding duplication of efforts. The activities that will fall under this effort to decentralize PMI support are the following: long-lasting insecticidal net (LLIN) distribution to antenatal clinic (ANCs), IRS, case management supervision, BCC implementation, and M&E supervision.

In the 2015 spray campaign, The PMI AIRS Project will work with the Mozambican National Malaria Control Program (NMCP) and other stakeholders to achieve at least 85 percent spray coverage of the 440,579 targeted structures located in six districts. The MOH will donate approximately 3,000 kgs of deltamethrin to The PMI AIRS Project to be used in Quelimane, Milange and Molumbo. PMI will fund the procurement of 3,724 kgs of organophosphate to be used in Mocuba, Morrumbala and Derre as these districts showed pyrethroid resistance during the resistance tests conducted by Abt in early 2015. In addition to spraying, the project will carry out the following activities:

- Support training, capacity building, and advocacy at the national, regional, and district level as a means to achieving IRS sustainability. This will include building the capacity of government, counterparts, and partners to undertake high-quality IRS. The AIRS Mozambique team will work towards increasing districts’ and DPS’s role in supervising IRS in 2015.
- Provide regular monitoring and evaluation (M&E) for The PMI AIRS project.
- Carry out a logistics assessment in all districts and arrange all procurement, shipping, delivery, and storage of spray tanks, spare parts, insecticides, and personal protective equipment (PPE).
- Prepare and submit the 2015 Supplemental Environmental Assessment (SEA).
- Ensure safe and correct insecticide application, thus minimizing human and environmental exposure to IRS insecticides, in compliance with the Safer Use Action Plan in the 2015 SEA.
- Coordinate information, education, and communication (IEC) and behavior change communication (BCC) sensitization and mobilization activities with other stakeholders to raise community awareness of IRS, and to encourage beneficiary and stakeholder ownership.

1 Districts were split in Zambézia Province: Milange was split into Milange and Molumbo, and Morrumbala was split into Morrumbala and Derre.
• Conduct routine entomological monitoring in all spray sites including assessing malaria vector density and species composition in intervention areas; establishing vector feeding time and location; monitoring the quality of insecticide application and insecticide decay rates; and assessing vector susceptibility and mechanisms of resistance.

• Small Studies or Hut Trials - To expand on PMI IRS Entomological Monitoring, the PMI IRS program may conduct small studies or hut trials to study new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPES evaluation and country-level required documentation has been submitted. The guidelines for laboratory testing and small and large-scale field trials are provided in Test procedures for insecticide resistance monitoring in malaria vector mosquitoes (WHO, April 2013).

• Conduct enhanced surveillance activities in selected health facilities in order to evaluate the impact of IRS.

• Promote cost efficiency through due diligence and efficiency of operations.

In 2012 USAID prepared the Management Programs for Malaria Vector Control: Programmatic Environmental Assessment (PEA) that provides a broad view of the human health and environmental impacts that could result from implementation of malaria vector control interventions. Supplemental Environmental Assessments (SEAs) must be developed to describe in-country impacts of interventions and describe country-specific activities to minimize those impacts.

The PMI IRS program prepared the Environmental Assessment for IRS using bendiocarb, DDT and lambda-cyhalothrin for Mozambique in February 2007. The following year, an SEA for the Mozambique IRS program was prepared in March 2008 and provided an assessment of WHO-approved IRS insecticides, carbamates, pyrethroids and DDT for PMI IRS in the Zambezia Province. In August of 2011, an updated SEA was prepared which only assessed pyrethroids in Zambezia Province.

This SEA addresses changes in the PMI IRS program and updates the information that was provided in previous SEAs. This SEA assesses the use of all WHO approved insecticides for IRS including pyrethroids, carbamates, organophosphates, and DDT. It also seeks approval to use chlorfenapyr, when recommended by WHOPES. Chlorfenapyr is currently under WHOPES review for IRS activities and is registered for agricultural, but not public health use by USEPA. Whereas the previous SEAs were only for PMI IRS activities in the Zambezia Province, this SEA is applicable for IRS activities nation wide and will allow the potential expansion of PMI IRS activities into all ten Mozambique provinces.

1.3 ADVERSE HEALTH AND ENVIRONMENTAL IMPACTS FROM IRS AND MITIGATION MEASURES

1.3.1 HEALTH IMPACTS

Based on U.S. Agency’s for International Development (USAID) experience with implementation of IRS in 17 other sub-Saharan African countries under the PMI, the most likely potential adverse health impact of the IRS intervention is unintentional pesticide exposure, leading to acute but mostly transitory health impacts on beneficiaries and spray operators. The short-term acute effects of DDT on humans are limited, but long-term exposures have been associated with chronic health effects. DDT has been detected in breast milk, raising serious concerns about infant health. Due to these potential impacts, when using DDT for IRS activities, all best management practices (BMPs) must be strictly adhered to, to ensure DDT is contained and that females employed by this project do not have any contact with the pesticide. These BMPs include strict enforcement of a 30 meter buffer zone around all sensitive
receptors such as water bodies, agriculture, apiculture, schools, playgrounds, and habitat for biological diversity and threatened species.

DDT stocks will be strictly accounted for on a daily basis by the sachet, utilizing best practices as detailed in the AIRS IRS Storekeeper Pocket Guide. Empty sachets will be inventoried and stored safely until destruction in a manner approved by the Basel Convention technical standards. It is unlikely to find the necessary equipment for destruction in Mozambique, so if PMI supports DDT use in Mozambique, the IP will assist the host country in identifying appropriate facilities and assuring appropriate destruction according to the standards in section 8.2.5 of this SEA.

The health effects from exposure to organophosphates (OPs) may not be transitory, and so exposure should be guarded against with greater vigilance. If the use of OPs is planned in the Mozambique IRS program, additional efforts must be made to train and sensitize all IRS personnel to the risks involved, the symptoms of OP toxicity, and the medical treatment protocol. As of this writing, PMI is determining if it is necessary to develop a cholinesterase-monitoring program for operators and others in potential close contact with these pesticides.

Another consideration with the use of currently-available organophosphate insecticides is the packaging, which consists of 1 liter plastic bottles. It is essential that spray operators perform a triple-rinse of the container while they are making up the spray solution in their tank, and that the rinsate is added to the tank as part of the final volume. This is to prevent subsequent contamination or exposure due to the residue that will otherwise remain in the bottle, and also to facilitate recycling or other downstream processing of the bottles. In order to prevent hazardous reuse of the bottles, they must be punctured upon return to the storehouse.

To mitigate risks of exposure, all individuals involved in the implementation of spraying – from spray operators to washpersons to storekeepers - will be provided with appropriate and adequate personal protective equipment (PPE), and will be trained in the best management practices contained in the PMI IRS Best Management Practices Manual (BMP)\(^2\). Community members will be informed on how to minimize direct and indirect exposure to insecticides (e.g., removing furniture and food from houses prior to spraying, keeping animals away, staying out of houses sprayed for two hours, sweeping dead bugs and properly disposing of them in pits or latrines, etc.).

Exposure treatment for carbamates, pyrethroids, DDT, chlorfenapyr and OP-based pesticides are detailed in Annexes B and C.

**1.3.2 ENVIRONMENTAL IMPACTS**

Since all of the WHOPES-recommended IRS insecticides except for malathion are hazardous for aquatic life, the highest risk to the environment is likely contamination to water resources, with subsequent die-off of fish and other aquatic life. The risk to bees, which are extremely sensitive to all these pesticides for malaria control except DDT, is also a consideration. Houses found within 30 meters of sensitive areas, including schools, core areas of national parks, habitat for protected species, water bodies and bee-keeping activities, will be noted by mobilizers, marked (physically, as well as by the use of GPS if available), and not sprayed. Beekeepers will be advised to move their hives at least 30 meters from any home for the day of spraying, or their home will not be sprayed. National and local regulations regarding protected areas have been researched, identified and will be followed by the IP.

DDT is persistent in the environment, and as much as 50% can remain in the soil 10-15 years after

application. It is also bio-accumulative, and is believed to have effects on many different species in the environment. (http://people.chem.duke.edu/~jds/cruise_chem/pest/effects.html ) Due to these characteristics and impacts, when using DDT for IRS activities, all best management practices must be strictly adhered to, to ensure DDT is contained and does not contaminate the environment.
1.4 **APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:**

The United States Agency for International Development's Global Health Bureau has determined that the proposed indoor residual spraying effort for the President's Malaria Initiative in Mozambique, as described in this Supplemental Environmental Assessment 2015-2020, responds to the needs of the community and country as it relates to managing malaria in Mozambique, as well as conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, documents the environmental planning and impact analysis executed by the IRS team in preparation for the proposed action. The design and standards of operation of the IRS program are established to avoid and reduce any potential impact. USAID has concluded that the proposed action, when executed as described in the Supplemental Environmental Assessment and the umbrella Programmatic Environmental Assessment (2012), is consistent with USAID's goal of reducing malaria incidence in Mozambique while minimizing negative impact to environmental and human health.

**CLEARANCE:**
Mission Director, USAID/ Mozambique ___________________________ Date: __________

Alexander Dickie

**CONCURRENCE:**
Bureau Environmental Officer, Global Health:

Rachel Dagovitz Date: 9/3/15

**ADDITIONAL CLEARANCES:**

PMI/CDC Team Leader
USAID/ Mozambique: ___________________________ Date: __________

James Coburn

Mission Environmental Officer
USAID/ Mozambique: ___________________________ Date: __________

Eduardo Langa

Regional Environmental Advisor, USAID/Southern Africa: ___________________________ Date: __________

David Kinyua

Environmental Officer
Africa Bureau: ___________________________ Date: __________

Brian Hirsch
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**CLEARANCE:**
Mission Director, USAID/ Mozambique: 

[Signature]
Date: 10/1/2015

**CONCURRENCE:**
Bureau Environmental Officer, Global Health:

[Signature]
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Eduardo Langa

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David Kinyua

Environmental Officer
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Date: 9/1/15
Alyssa Leggoe, IHO Chief
Date: 9/24/15
Sheila Young, PRO
Date: 9/29
Beverly Hadley, RLO
Date: 10/1/15
Sheryl Stumbras, DMD
Date: 10/1/15
Alex Dickie, MD
Date: 11/4/15
1.4 **APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:**

The United States Agency for International Development’s Global Health Bureau has determined that the proposed indoor residual spraying effort for the President’s Malaria Initiative in Mozambique, as described in this Supplemental Environmental Assessment 2015-2020, responds to the needs of the community and country as it relates to managing malaria in Mozambique, as well as conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, documents the environmental planning and impact analysis executed by the IRS team in preparation for the proposed action. The design and standards of operation of the IRS program are established to avoid and reduce any potential impact. USAID has concluded that the proposed action, when executed as described in the Supplemental Environmental Assessment and the umbrella Programmatic Environmental Assessment (2012), is consistent with USAID’s goal of reducing malaria incidence in Mozambique while minimizing negative impact to environmental and human health.

**CLEARANCE:**
Mission Director, USAID/ Mozambique __________________________Date: _____________

*Alexander Dickie*

**CONCURRENCE:**
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*Rachel Dagovitz*

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Environmental Officer
Africa Bureau: __________________________Date: _____________

*Brian Hirsch*
2. Purpose of this Document

Under the U.S. Code of Federal Regulations (22 CFR §216), malaria vector control activities supported or planned by USAID must undergo environmental examination. To assist USAID missions in planning malaria vector control interventions, USAID in 2012 prepared the Management Programs for Malaria Vector Control: Programmatic Environmental Assessment (PEA) that provides a broad view of the human health and environmental impacts that could result from implementation of malaria vector control interventions. However, the PEA cannot account for inter-country and interregional variation regarding issues such as the capacity to manage pesticides used for vector control and the environment likely to be impacted. For this reason, Supplemental Environmental Assessments (SEAs) must be developed to describe in-country impacts of interventions and describe country-specific activities to minimize those impacts.

Whenever an in-country malaria vector control activity involves “assistance for the procurement or use, or both, of pesticides,” SEAs supplementing the PEA must address the pesticide procedures found in 22 CFR 216.3(b). The pesticide procedures list 12 factors to address in SEAs which are described in the Pesticide Procedures section of this document.

In sum, the SEA should be looked upon as the overall representation of the country with regard to IRS. The SEA should address the human health and environmental impacts that may occur as a result of USAID support of malaria vector control activities.

The purpose of a malaria program is to save lives and reduce illness and suffering. The purpose of the SEA is to optimize these goals by ensuring malaria control programs use only safe and efficacious pesticides and use them in the way that will minimize inadvertent poisonings and intoxications; by ensuring the natural resources on which people depend for their daily food production and nutrition are not damaged; by ensuring that long term development is promoted by avoiding disruption of agricultural exports due to misuse of malaria pesticides on agricultural crops; and, by preserving unique cultural and natural resources and features.

The PMI IRS program prepared the Environmental Assessment for IRS using bendiocarb, DDT and lambda-cyhalothrin for Mozambique, in February 2007. The following year an SEA for the Mozambique IRS program was prepared in March 2008 and provided an assessment of WHO-approved IRS insecticides, carbamates, pyrethroids and DDT for use in the Mozambique Malaria Control Program in the Zambezia Province.

In August of 2011, an updated SEA was prepared in accordance to USAID Reg 216. This SEA assessed the use of WHOPES-recommended pyrethroids for use in the Mozambique Malaria Control Program in eight select districts in the Zambezia Province. Due to an environmental sampling conducted in 2008, 2009 and 2010 that demonstrated increased levels of DDT in crops stored in homes and in the soils surrounding houses, DDT was withdrawn from the PMI program.

This SEA addresses changes in the PMI IRS program and updates the information that was provided in previous SEAs. This SEA assesses the use of all WHOPES recommended pesticides for IRS including pyrethroids, carbamates, organophosphates, and DDT. It also includes chlorfenapyr, which is currently under WHOPES review for IRS and is registered for agricultural, but not public health use by USEPA. Whereas the previous SEAs were only for PMI IRS activities in the Zambezia Province, this SEA is applicable for IRS activities nation-wide and will allow the potential expansion of PMI IRS activities into all ten Mozambique provinces.
Upon approval of this SEA, a Letter Report will be submitted to USAID annually that will discuss new features of the IRS program for that particular year’s spray campaign. If the first use of organophosphates is anticipated in the given year, as per the requirements in the PEA the Letter Report must be signed by the Africa Bureau and Global Health BEOs. Use of organophosphates in subsequent years does not require BEO signatures. The preparation of this SEA update renders the preparation of a Letter Report unnecessary for 2015.
3. BACKGROUND

3.1 BACKGROUND TO THE PROPOSED ACTION

The PMI was launched in June 2005 as a 5-year, $1.2 billion inter-agency initiative to rapidly scale up malaria prevention and treatment interventions and to reduce malaria-related mortality by 50% in 15 high-burden countries in sub-Saharan Africa. Mozambique was selected as a PMI country in fiscal year (FY) 2007. PMI’s primary goal in Mozambique is to assist the Government of Mozambique (GoM), in collaboration with other partners, to reduce malaria mortality by 50% by rapidly scaling-up coverage of vulnerable groups with four highly effective interventions: artemisinin-based combination therapy (ACT), intermittent preventive treatment of pregnant women (IPTp), insecticide-treated bed nets (ITNs), and indoor residual spraying (IRS).³

The 2008 Lantos-Hyde Act extended PMI program funding through FY 2014. In May 2009, President Barack Obama announced the Global Health Initiative (GHI), a multi-year, comprehensive USG effort to reduce the burden of disease and promote healthy communities and families around the world. The Strategic Vision is that the United States will continue to provide global leadership in reducing preventable malaria deaths to near zero by 2015 and strive toward the ultimate goal of eradication. Through the GHI, the USG provides assistance to partner countries to improve health outcomes, with a particular focus on improving the health of women, newborns, and children. PMI immediately became a core component of the GHI, along with the USG’s global health programs for HIV/AIDS (the President’s Emergency Program for AIDS Relief, PEPFAR) and tuberculosis and, included the USG’s support for GFATM. The USG closely aligned its support for PMI, PEPFAR, and GFATM through various steering and oversight committees with funding processes within the GHI framework. Within the USG, the U.S. Agency for International Development (USAID) Mozambique Health Team has merged into one Integrated Health Office, maximizing the programmatic synergies among the President’s Emergency Plan for AIDS Relief (PEPFAR), PMI, and other health programs.

Programming of PMI activities has been aligned to follow the core principles of GHI: encouraging country ownership and investing in country-led plans and health systems; increasing impact and efficiency through strategic coordination and programmatic integration; strengthening and leveraging key partnerships, multilateral organizations, and private contributions; implementing a woman- and girl-centered approach; improving monitoring and evaluation (M&E); and promoting research and innovation.

3.2 MALARIA BURDEN IN MOZAMBIQUE

Malaria is endemic throughout Mozambique, and its entire estimated population of 24 million people is at risk of malaria. Most of the country has year-round malaria transmission with a seasonal peak during the rainy season, from December to April. In addition, Mozambique is prone to natural disasters such as drought, cyclones, and floods, which may have contributed to increases in malaria transmission in recent years, particularly in low-lying coastal areas and along major rivers.

Malaria is considered the most important public health problem in Mozambique and accounts for 29% of

³ PMI Mozambique MOP FY 2014
all deaths, followed closely by AIDS at 27%. Among children less than five years old, malaria accounts for 42% of the deaths, followed by AIDS at 13%. *Plasmodium falciparum* accounts for 90% of all malaria infections, with *P. malariae* and *P. ovale* responsible for about 9% and 1%, respectively.

The recent 2011 Demographic and Health Survey (DHS) data show that malaria prevalence, using rapid diagnostic tests (RDTs), varies from 1.5% in the capital, Maputo, to 54.8% in Zambézia Province. Prevalence rates are generally higher in the northern region, varying from 43.3% to 52.1%, and lower in the southern region, varying from 1.5% to 36.8%. In the central region, the prevalence varies from 30% to 37%, except for Zambézia with 54.8%. The prevalence in rural areas is almost three times as high as the prevalence in urban areas, 46% versus 16%, respectively. The major vectors in Mozambique are *Anopheles gambiae* s.s., *An. arabiensis*, and *An. funestus* s.s. Of the major subspecies of the *An. gambiae* complex, *An. arabiensis* is more prevalent in the south and *nA. gambiae* in the north.4

3.3 **HISTORY OF MALARIA CONTROL IN MOZAMBIQUE**

Malaria control activities in Mozambique date back to the 1950s, when the global malaria eradication program was initiated. However, the National Malaria Control Program (NMCP) wasn’t established until 1982. In 1991, the NMCP formally adopted three main strategies, namely: Early Diagnosis of Malaria (clinical and laboratory) and its appropriate treatment, Vector Control and Health Promotion.

In 1999, a joint international consultancy mission carried out a brief malaria situational analysis, which was followed by a written analysis by the Ministry of Health (MISAU). They concluded that these malaria control strategies had not been effective in Mozambique for the following reasons:

- The National Health System (NHS) lacked the capacity to reach the majority of the rural population;
- Health infrastructures were insufficient after sixteen years of civil war and destruction, and linkages between health services and the community were weak;
- Chloroquine resistance and the limited availability of drugs at community level;
- Residual spraying campaigns against mosquitoes were concentrated in urban areas;
- Health promotion, information and communication often failed to reach the target population, and has been ineffective;
- The population had limited capacity to recognize important malaria signs and symptoms, and certain cultural practices prevent people from seeking health care.

In response to this situation, MISAU adopted a new approach for its malaria control program, in line with the Roll Back Malaria initiative for the African region. The strategy aimed to promote civil society involvement in health, focusing on the capacity at family level to prevent, recognize and, when necessary, manage malaria appropriately or go to a health facility. This strategy targeted children under five and pregnant women. Malaria is also regarded as a priority, both in the Poverty Reduction Paper and the Health Sector Strategic Plan.5

Similar situational analyses were undertaken in 2000 in the districts of Moatize, Massinga, Quelimane, Angoche, Mocuba and Manhiça. The outcomes from those analyses formed the basis for the development of the Mozambican Strategic Plan for the Roll Back Malaria initiative. The initial Strategic Plan was developed in 2003-2006, which was then updated in the 2006-2009. The most recent 2012-

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4 PMI MOP FY2014
5 MOH Strategic Plan for Malaria Control in Mozambique 2006-2009.
2016 NMCP Strategy Plan provides the NMCP with a malaria control strategy that has clear objectives and targets and indicators to monitor and evaluate, in order to facilitate effective implementation of interventions of prevention and control of malaria in Mozambique.

MISAU has been supporting limited IRS operations in peri-urban and urban areas throughout Mozambique since the 1960’s eradication era. These MISAU activities suffered from a lack of financial and skilled human resources. The quality and impact of these small-scale activities is unknown but probably was very limited. Mozambique expanded its IRS program to 25% of the population in 2006 and 30% in 2007, with IRS taking place in 46 different districts (partial coverage) out of 146 districts countrywide.

In 2007 Mozambique was selected as one of the four countries to receive funding during the second year of the President’s Malaria Initiative. The PMI Year 1 Malaria Operational Plan for Mozambique was developed in close consultation with the National Malaria Control Program and with participation of nearly all national and international partners involved with malaria prevention and control in the country.

The MISAU-led IRS program in Zambézia Province began in 2005 in three districts (Quelimane, Namacurra, and Nicoadala) and used DDT. It was then expanded into parts of three additional districts (Morrumbala, Mocuba, and Milange) in 2006. In 2007, the NMCP and provincial health authorities requested PMI to support the spraying operations in those six districts.

Indoor residual spraying remains a high priority vector control intervention for MISAU/MOH in Mozambique. In 2011, PMI achieved a 99% coverage rate with IRS operations covering more than 660,000 structures and protecting approximately 2.8 million people in eight of the 17 districts in Zambézia. Due to funding constraints, the IRS campaign supported the spraying of six districts in Zambézia in 2012, targeting approximately 573,000 structures and 2.4 million people. In 2012, PMI initiated enhanced epidemiologic surveillance, in addition to entomologic surveillance, in the two districts where IRS was stopped. This epidemiologic and entomologic surveillance also took place in the six districts where PMI conducted IRS operations. In 2012, insecticides for the MISAU IRS activities that were being procured by the Global Fund not only arrived very late, but only 4.8% of the requested amount was supplied, resulting in the cancellation of the MISAU national IRS campaign. In 2013 PMI’s IRS operations were further reduced to four districts, covering a total of 414,232 structures with 89.2% coverage.⁶

### TABLE 1. STRUCTURES AND POPULATION PROTECTED BY IRS, ZAMBEZIA PROVINCE, 2007–2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Districts</th>
<th>Number of Structures Sprayed</th>
<th>Population Protected</th>
<th>Insecticide</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007*</td>
<td>Sept/Nov</td>
<td>6</td>
<td>363,962</td>
<td>1,572,413</td>
<td>DDT</td>
</tr>
<tr>
<td>2008*</td>
<td>Oct/Dec</td>
<td>6</td>
<td>412,433</td>
<td>1,457,142</td>
<td>DDT</td>
</tr>
<tr>
<td>2009*</td>
<td>October/December</td>
<td>6</td>
<td>560,023</td>
<td>1,985,729</td>
<td>PY/DTT (Mocuba only)</td>
</tr>
</tbody>
</table>

⁶ PMI MOP FY07, FY08, FY09, FY10, FY11, FY12, FY13.
<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Districts</th>
<th>Number of Structures Sprayed</th>
<th>Population Protected</th>
<th>Insecticide</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010*</td>
<td>Sept/December</td>
<td>8</td>
<td>618,290</td>
<td>1,943,643</td>
<td>PY</td>
</tr>
<tr>
<td>2011*</td>
<td>Sept/December</td>
<td>8</td>
<td>660,762</td>
<td>2,018,730</td>
<td>PY</td>
</tr>
<tr>
<td>2012</td>
<td>Oct/Dec</td>
<td>6</td>
<td>536,558</td>
<td>2,181,896</td>
<td>PY</td>
</tr>
<tr>
<td>2013</td>
<td>Oct/Dec</td>
<td>4</td>
<td>414,232</td>
<td>2,181,896</td>
<td>PY</td>
</tr>
<tr>
<td>2014</td>
<td>Oct/Dec</td>
<td>5</td>
<td>404,707</td>
<td>2,327,910</td>
<td>PY</td>
</tr>
<tr>
<td>2015</td>
<td>Oct/Nov**</td>
<td>6***</td>
<td>440,579</td>
<td>2,177,912</td>
<td>PY / OP</td>
</tr>
</tbody>
</table>

1. * 2007 – 2011 data source is Mozambique MOH
2. **Targets for Oct 2015
3. *** Note that Milange and Morrumbala were each split into two districts in late 2014 by the Government of Mozambique. Derre was part of Morrumbala District and Molumbo was part of Milange District.

**LSDI**

The Lubombo Spatial Development Initiative (LSDI) was a public-private trilateral program of the governments of Mozambique, South Africa and Swaziland to develop the Lubombo region into a globally competitive zone for trade and tourism. Since malaria was identified as a major deterrent to development, the LSDI developed a specific program with the aim of reducing malaria throughout the region. LSDI introduced IRS in 2000 in the south of Maputo Province using bendiocarb (because of high levels of *An. funestus* resistance to pyrethroids) in two spray rounds a year and was incrementally extended to cover seven districts by 2004. It continued to expand, and in 2007 they were also working in three districts in Gaza Province. Further expansion in subsequent years was expected to cover a population of approximately one million residents by 2009 in the southern region of Mozambique. The LSDI project was very successful, but ended in late 2010 when the Global Fund withdrew support due to mismanagement of the grant.

### 3.4 USAID STRATEGIC APPROACH

PMI support to Mozambique is in line with the GoM’s 2012-2016 National Malaria Control Strategy. Funding is targeted to fill gaps in activities not already supported by the NMCP, Global Fund, or other donors. PMI support is also targeted to translating best practices in malaria prevention and control to areas and activities currently supported by other funding agencies.

Supported activities continue to focus on achieving and maintaining high coverage of LLINs, particularly among the vulnerable populations of pregnant women and children under five, targeting IRS to complement national universal coverage campaigns, providing SP and support for IPTp scale-up, and improving case management, along with supportive activities such as BCC, strengthening supply chain management, and M&E.

PMI plans to decentralize its support to the provincial and district level. The objective of this approach is to improve implementation of malaria-related activities through the facilitation of supervision, distribution of commodities, and M&E. PMI will establish a provincial-level platform for BCC, MIP interventions, M&E, and case management in four provinces (Nampula, Cabo Delgado, Zambézia, and Tete). These provinces have been selected because of their high burden of malaria and the presence of strong local partners. In provinces where the USG has existing partners, efforts will be made to use
these existing mechanisms, thereby following the GHI mandate and avoiding duplication of efforts. The activities that will fall under this effort to decentralize PMI support are the following: LLIN distribution to ANCs, IRS, case management supervision, BCC implementation, and M&E supervision. (MOP FY 2014)

3.5 **PMI Program Objectives**

In 2015, PMI launched the next six-year strategy, setting forth a bold and ambitious goal and objectives. This PMI Strategy for 2015-2020 takes into account the progress over the past decade and the new challenges that have arisen. Malaria prevention and control remains a major U.S. foreign assistance objective and PMI’s Strategy fully aligns with the U.S. Government’s vision of ending preventable child and maternal deaths and ending extreme poverty. It is also in line with the goals articulated in the draft RBM Partnership’s second Global Malaria Action Plan and WHO’s draft Global Technical Strategy. Under the PMI Strategy for 2015-2020, the U.S. Government’s goal is to work with PMI-supported countries and partners to further reduce malaria deaths and substantially decrease malaria morbidity, towards the long-term goal of elimination.

Building upon the progress to date in PMI-supported countries, PMI will work with NMCPs and partners to accomplish the following objectives by 2020:

1. Reduce malaria mortality by one-third from 2015 levels in PMI-supported countries, achieving a greater than 80% reduction from PMI’s original 2000 baseline levels.

2. Reduce malaria morbidity in PMI-supported countries by 40% from 2015 levels.

3. Assist at least five PMI-supported countries to meet the World Health Organization’s (WHO) criteria for national or sub-national pre-elimination.

These objectives will be accomplished by emphasizing five core areas of strategic focus:

- Achieving and sustaining scale of proven interventions
- Adapting to changing epidemiology and incorporating new tools
- Improving countries’ capacity to collect and use information
- Mitigating risk against the current malaria control gains
- Building capacity and health systems towards full country ownership

3.6 **Institutional Framework for Malaria Control**

3.6.1 **National Malaria Control Program**

The *Programa Nacional de Control da Malaria* (PNCM) or NMCP was created as a unit within the Epidemiology Section and Department of Epidemiology and Endemic Diseases. It is part of the Communicable Diseases Unit which implements integrated strategies for disease control.

The NMCP is subordinate to the area of Disease Prevention and Control (PCD) in the National Directorate of Public Health (DNSP). Malaria control services are decentralized to the provincial and district levels. Regardless of the position of the NMCP in organizational structure, the program director can make decisions and respond directly to the Minister of Health when necessary.

At provincial level, the implementation and coordination of health services management is under the
responsibility of the DPS, more specifically, the Chief Medical Doctor. The recently created position of Provincial Coordinator for Malaria, STI/HIV/AIDS, TB/Leprosy reports directly to and supports the Provincial Chief Medical Doctor. At district level, the district health team is responsible for implementation and coordination of disease control activities.

The NMCP collaborates with other areas of the MISAU/MOH, particularly Maternal and Child Health (MCH), the Health Promotion Department (DPROS), section of clinical laboratories, Pharmaceutical Department, the Center for Medicines and Medical Articles (CMAM), the Supply Centre, the Executive Manager of Acquisition Unit, the Department of Information (DIS), the Department of Epidemiology, the National Institute of Health (INS) and others.

In 2005, the National Malaria Control Commission (NMCC) was established, as a decision-making board led by the MISAU. The scope of the NMCC includes policy orientations and relevant strategies for malaria control in Mozambique, namely vector control (including LLIN and IRS), malaria case management, monitoring and evaluation, operational research, and IEC. It is a multi-disciplinary commission comprising senior management officials from MISAU. In concrete terms, the commission is comprised of Senior Clinicians, the NMCP Manager, the Heads of the Pharmaceutical, Administration and Management and Community Health Departments, the head of the Department of Health Promotion, the INS Scientific Manager and representatives from the Pharmacology Department at the Faculty of Medicine, Eduardo Mondlane University. The NMCC may invite senior representatives within MISAU and other relevant sectors, in particular DPS, DDS, Ministries of Education, Agriculture, Industry and Commerce, Environment and Finance, as well as representatives from the private sector that support malaria control activities. The NMCC has the back up of technical groups for each of the specific strategies responding to specific issues. In turn, these technical groups report to the Commission.

Besides the NMCC, there is a partners' forum directly involved in malaria control (Malaria Control Technical Coordination Committee), which supports policy design and strategy development, including relevant operational aspects of the NMCP. Members include WHO, UNICEF, USAID, Malaria Consortium, PSI, CISM (Manhiça Research Centre), and the INS.

There is a forum of partners who work directly with the NMCP in the fight against malaria (malaria technical group), which assists in the design of policies and strategies, as well as operational aspects relevant to the NMCP. The principle partners include the following:

- Bilateral and multilateral agencies: GF, USAID/PMI, DFID, World Bank, UNICEF, WHO
- International NGOs: World Vision, FHI, HAI/MACEPA, PSI, RTI, JSI Deliver, Malaria Consortium, Agakhan, MdMP, IRD, JHPIEGO/MCHIP, C-Change
- Local NGOs: FDC, PIRCOM, network of Journalists against Malaria
- Government Institutions: National Institute of Health, National Institute of Traditional Medicine, research center of Manhiça, National Institute of statistics, National Institute of Meteorology, National Disasters Management Institute, CTTF, Military Health
- Training institutions: Higher Institute of Health Sciences, EMU

7 PNCM. Plano Estrategico da Malaria 2012-2016
In an effort to ensure sustainable development in its drive for economic growth, the Government created the *Ministério para a Coordenação da Ação Ambiental* (MICOA) shortly after the holding of the first election in 1994. Since 1994, MICOA has developed a legal framework for environmental management, with the following the essential elements:

- National Environmental Management Programme (MICOA 1996)
- Framework Environmental Act (No. 20 of 1997)
- EIA Regulations (Decree No. 76 of 1998), and
- EIA guidelines

In addition to the formulation of environmental policies, laws and regulations, other important legal instruments that contribute to improved environmental management include the Land Act (No. 19 of 1997) and the Forestry and Wildlife Act (No. 10 of 1999).

**The National Environmental Management Programme**

One of MICOA’s first tasks was to formulate the NEMP to promote and implement sound environmental policy. The NEMP (MICOA 1996) was approved by the Council of Ministers in 1996 and contains an ‘Environmental Policy’, a proposal for the ‘Framework Environmental Act’ (subsequently passed in 1997) and an ‘Environmental Strategy’.

**The Framework Environmental Act**

The Framework Environmental Act aims to provide a legal framework for the use and correct management of the environment and its components and to assure the sustainable development of Mozambique.

Chapter 4 of the Act refers to the ‘Prevention of Environmental Damage’. Under this clause, licensing of activities that are liable to cause significant environmental impacts is required. The issuance of an environmental license is dependent on an appropriate level of EIA being completed and accepted by MICOA.

Importantly, the Framework Environmental Act obliges all sectoral legislation that deals in any way with the management of components of the environment to be reviewed and revised so that it is in conformity with the new Act (Article 32).

A National Commission for Sustainable Development, linked to the Council of Ministers, was created in October 2000 by a provision in the Act. This Commission seeks to ensure the effective coordination and integration of sectoral policies and plans related to environmental management at the highest level.

**The Land Act**

The Land Act, its Regulations (Decree No. 66 of 1998) and Technical Annex (Ministerial Diploma No. 29-A of 2000) provide the legal framework for the ownership and control of land and natural resources in Mozambique. The Act recognizes the need to protect ecologically sensitive areas through the creation of protected areas and, therefore, provides an additional legal basis for demarcating areas for protection and conservation (Article 5) and the creation of total and partially protected zones (Article 6). Importantly, the Act also recognizes the rights of local communities over land and natural resources thereby offering the possibility of involving rural communities fully in the management and conservation of natural resources (Article 31).

**The Forestry and Wildlife Act**
In 1997, the Government adopted a new Forestry and Wildlife Policy and Strategy (GRM 1997). In accordance with the objectives of the Forestry and Wildlife Policy and Strategy, a new Forestry and Wildlife Act was passed. The Act confirms the rights of the State over natural forest and wildlife resources in the country, although private individuals, organizations and local communities may have access to these resources by way of licenses and concessions. However, an essential principle of this Act is that local communities must be fully involved in the conservation and sustainable use of forestry and wildlife resources.

**General EIA guidelines**
In 2001, EIA guidelines were prepared and distributed (MICOA 2001) that are applicable to a variety of development projects. These describe, *inter alia*, in more detail the environmental parameters that need to be measured during an EIA and the process for identifying alternatives.

**Devolution of responsibilities, including EIA**
In order to discharge its mandate more effectively, and in line with the Government’s decentralization policy, MICOA has been establishing an increasing institutional presence at lower government levels since 1995 and Provincial Directorates have been set up in all ten Provinces. However, since district-level government structures are evolving only very slowly and selectively, MICOA is not yet formally institutionalized below provincial level anywhere in the country. However, in practice, the envisaged role of MICOA’s provincial structures continues to be strongly curtailed by the severe lack of institutional capacity, and central ministry staff often continue to be involved in monitoring and enforcement activities at the provincial level.

**Integration of environmental considerations in other government sectors**
MICOA’s efforts to coordinate environmental matters with other government ministries and departments face various challenges, including:

- Inconsistencies and contradictions in substance and style across ministries and departments regarding environmental management because roles, positions and modes of cooperation are still evolving
- Limited human resources and institutional capacity, not only at MICOA but also in other government sectors and especially at the provincial level
- Lack of clarity and overlap of environmental management roles and responsibilities among government sectors
- The lack of a culture of communication, information-sharing and cooperation between institutions, and
- Planning, operational and human resource constraints in linking the evolving environmental monitoring and enforcement activities at provincial level to the central level.

### 3.6.3 Pesticide Regulations and Control
The Mozambique Ministry of Agriculture and Risk (MINAGRI) is responsible for overseeing the Pesticide Regulation (Regulamento Sobre Pesticidas; Ministérios da Agricultura e Desenvolvimento Rural, da Saúde, e para a Coordenação da Ação Ambiental, Diploma Ministerial No. 153/200 de 11 de Setembro (BR No. 37, I Série de 11 de Setembro de 2002)) that applies to the registration, importation, distribution and application of pesticides for agriculture, livestock and public health. MINAGRI also manages a list of pesticides that have been registered for use in Mozambique, including pesticides for public health.

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*Hatton, John, Telford, Steven, Krugmann, Hartmut. Mozambique. 2002.*
The following is a summary of the relevant aspects of the Pesticide Regulation:

**Procedures for obtaining registration**
All substances containing pesticides or plant growth regulators to be imported, produced, marketed and used in the country are subject to a prior registration. Registration is granted by registration authority upon a request. The technical and scientific data needed for the evaluation of pesticides includes the physical-chemical, toxicological, ecotoxicological properties and biological metabolism and residues. Label requirements, packaging characteristics and criteria for toxic classification and its impact on the environment, are contained in the rules for the registration and handling of pesticides. On delivery of the request, the applicant must pay a fee set by the registration authority.

**Evaluation**
The pesticide registration is carried out based on the evaluation of the efficacy and safety of the product, to ensure that under normal conditions of use, it is within the acceptable toxicological standards for human, animal and environmental health. During the evaluation product samples for testing purposes or technical formulations of the active ingredient may be required.

**Composition and specifications**
The composition and physical-chemical properties of pesticides proposed for registration shall conform to the specifications of the World Health Organization (WHO) or the United Nations Food Organization (FAO) and must appear on the label. When these specifications do not exist, the registration authority may consider the specifications provided by the manufacturer. The specifications label on the active substances must match those contained in the pesticide and comply with international standards.

**Toxicological classification**
The toxicological classification of pesticides is based on the 50% lethal Dose (LD$_{50}$) for oral or dermal, and 50% lethal concentration (LC$_{50}$) for inhalation exposures. Pesticides are placed into one of three classes: class I - highly toxic (label with red stripes); class II - moderately toxic (label with yellow stripes); and class III - slightly toxic (label with green stripes).

**Authorization of pesticides for Public Health activities**
Public health pesticides are broken down into 2 groups: a) pesticides for domestic (homeowner) use b) pesticides for professional use in vector control. Pesticides for domestic use are subject to registration, import, distribution and application requirements defined by the registration authority, as laid down in the rules for the registration and handling of pesticides. Pesticides for professional use in vector control are subject to the normal registration procedures and should also be tested by the MISAU/MOH's DNSP.

Public health pesticide labels must be written in Portuguese and include the registrant, product identification and active substance, purpose and mode of application, safe use and disposal of packaging after use, as well as the procedures for first aid in case of poisoning.

**Importation of Pesticides**
The entity intending to import pesticides, whatever their amount, should obtain a certificate of registration as an importer of pesticides.

**Pesticide storage**
The store manager shall, in coordination with the INNOQ (National Institute of Standardization of Quality, MISAU and MICOA, follow all technical standards concerning storage conditions for pesticides.
based on the FAO directives. The pesticides should be stored in isolated compartments and locked, properly ventilated, out of reach of children and unauthorized persons, and always properly separated from food, animals, and medicines.

**Application of pesticides**
Only pesticides that are registered, or authorized for emergency or experimental use, can be used. The pesticides should always be applied in accordance with the particulars given on the label, bearing in mind proper protection practices and, whenever possible, the principles of integrated pest management of pests and diseases. These practices must minimize the risk to the applicator, consumers, non-target organisms, the general population and the environment.

**Transport of pesticides**
All vehicles must be authorized to carry pesticides based on quantities greater than or equal to the following: i) 200 pounds or liters of pesticides of class I; ii) 1,000 pounds or liters of pesticides of Class II; iii) 2,500 litters of pesticides Class III. Only drivers approved by the registration authority or his representative shall transport pesticides on public roads as per the quantities listed above.

**Disposal of pesticides**
The disposal of pesticides or their relocation to approved locations can only be undertaken after prior authorization from the central or Provincial Services of MITADER, with consensus from MISAU and MICOA. Registration authority, MISAU, MICOA and INNOQ, will establish the procedures for pesticide disposal.

**Training**
Companies or entities that employ people to store, handle, transport or apply pesticides are responsible for training on the following: rules for transport, storage, application, fire safety, intoxications, spills, disposal and safe handling practices.

**Obsolete pesticides**
It is prohibited to distribute obsolete pesticides. Organizations, users, companies or other entities that have obsolete pesticides shall communicate in writing to the registration authority, detailing the type of active substance, the trade name, quantity, type of packaging, the location of the product as well as reasons of obsolescence.

**Supervision**
The supervision of the importation, storage conditions, application, production, distribution, disposal and quality control of pesticides will be made by technical personnel accredited by the National Directorate for Impact Environmental Assessment (DINAIA) or a legal representative thereof. The inspection team will include MICOA and MISAU staff. Testing and control of Maximum Residue Limits for Pesticides will be done by the MOH Hygiene of Food and Water national laboratory.

**Competence to oversee**
Technical staff authorized and indicated by the registration authority to carry out an inspection has a right of access to all establishments or places of production, storage, distribution and application of pesticides.

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9 Translated from Regulamento Sobre Pesticidas; Ministérios da Agricultura e Desenvolvimento Rural, da Saúde, e para a Coordenação da Acção Ambienta.
3.6.4 **International Conventions**

The following are the Multilateral Environmental Agreements to which Mozambique is a party:

- Convention on Biological Diversity
- Cartagena Protocol on Biosafety to the Convention on Biological Diversity
- Convention to Combat Desertification
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on the International Hydrographic Organization
- Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and Southeast Asia
- International Plant Protection Convention
- Vienna Convention for the Protection of the Ozone Layer
- Montreal Protocol on Ozone Depleting Substances
- United Nations Framework Convention on Climate Change
- Kyoto Protocol
- Stockholm Convention onPersistent Organic Substances
- Ramsar Convention
- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
- Basel Convention on the Trans boundary Movement of Hazardous Wastes and their Disposal
- Bamako Convention on the ban of Import into Africa and the Control of Trans boundary Movement and Management of Hazardous Wastes within Africa
- International Tropical Timber Agreement, 2006

3.7 **Mozambique Malaria Control Activities**

3.7.1 **Vector Control Activities**

Malaria prevention through Integrated Vector Management (IVM) incorporates various vector control interventions, selected on the basis of the local factors that determine malaria transmission, including the following:

- **IRS** - effective method for controlling indoor resting adult mosquitoes, which can result in reducing the level of malaria transmission.
- **LLINs** - provides both personal and community level protection from mosquitoes
- **Environmental management/larval control** (includes all physical, chemical and biological methods) - larval mosquito vector control of malaria has the potential to be effective whenever the breeding targets are well defined and are limited in number, particularly in the sub and peri-urban areas.
• Entomological monitoring - ensures the assessment of vector density, the susceptibility of vectors to insecticides and residual efficacy of pesticides used on IRS and LLINs.

• Pulverização Extra-Domiciliária – Exterior household spraying is a vector control method for emergency situations

IRS continues to be a priority in vector control interventions. The Government of Mozambique has performed IRS since 1946. According to the annual report of the NMCP, about 2.3 million homes were sprayed in 2010 which corresponded to 71% coverage and 9.5% of the total population. IRS increased from 34 districts in 2001, to 54 in 2009 and 62 in 2010. The number of Districts covered by the NCMP has varied from year to year. For example: in 2011, a total of 52 Districts were covered; however in 2012 only 6 districts were sprayed because of the late arrival of the pesticide. In 2013 a total of 58 districts were covered, and in 2014 coverage was down to 36 districts. The NMCP is projected to spray 21 Districts in 2015. The program uses DDT, pyrethroids and carbamates for IRS, which are insecticides recommended for IRS by the World Health Organization (WHO).

The distribution of LLINs started in 2000 for children under five years and pregnant women. According to NMCP data, 7.6 million nets were distributed from 2007 to 2010. According to the annual report of 2010, NMCP achieved 84.6% coverage of pregnant women.

The implementation of mass universal coverage campaigns started in calendar year 2010 in 11 (out of a total of 151) districts; in 2011 universal coverage campaigns were carried out in 45 districts. During calendar year 2012, the MOH carried out Global Fund and World Bank-supported mass universal coverage campaigns in 21 districts. In calendar year 2013, more than 2.2 million nets were distributed in 23 districts. The MOH has since distributed an additional 5.2 million ITNs in 64 districts, completing coverage of all districts initially targeted for universal ITN distribution and beginning to cover districts that formerly received only IRS, as well as net replacement, which was originally scheduled for every three years.

Larval control and the reduction of potential breeding grounds are not common practices, and only are implemented in specific geographic locations. To be successful, this activity requires multi-sectoral and community involvement.

3.7.2 ENTOMOLOGICAL MONITORING

The NMCP is interested in expanding regional entomology capacity and decentralization of entomologic monitoring/surveillance, which otherwise would be too costly and logistically difficult to support on a routine basis from the central laboratory in Maputo.

PMI has provided a significant amount of support to build Mozambique’s entomological capacity both at the central level and regionally. The PMI-supported central entomology laboratory and insectary at the National Institute of Health (INS) in Maputo is operational and serves as the reference laboratory for in-country processing of mosquito material, such as polymerase chain reaction species identification of mosquito complexes, enzyme-linked immunosorbent assays for malaria-infected mosquitoes, monitoring for insecticide resistance and its mechanisms by both above-mentioned methods, and insecticide efficacy monitoring for IRS and LLINs nationwide.

The PMI-supported entomology laboratory and insectary in Quelimane, Zambézia Province, serves as a

10 PNCM. Plano Estrategico da Malaria 2012-2016
regional center for entomologic monitoring and surveillance for IRS and LLIN activities in the central provinces of Mozambique. In a collaborative effort between PMI and the DPS in Zambézia, the Quelimane entomology laboratory has been staffed by four DPS personnel trained in basic entomologic field techniques, as well as insectary maintenance. PMI has provided funding for short-term technical assistance visits by entomologists from other African countries.

Similarly, the PMI-supported entomology laboratory in Pemba, Cabo Delgado Province, serves as a regional center for entomological monitoring and surveillance in the northern provinces. It is currently staffed by a DPS biologist who was trained in a WHO/PMI supported workshop in 2008, and by three technicians from the DPS. Due to the lack of entomologists at the central level, PMI in 2009 also hired an entomologist to provide two years of technical assistance to the NMCP on national entomology surveys and IRS surveillance in Zambézia.

In November 2012, the INS funded a three-week training course for an entomologist from their entomology team at the Centers for Disease Control and Prevention (CDC). The training included molecular methods for mosquito species identification, molecular and biochemical methods for resistance mechanisms, and the bottle bioassay for evaluating insecticide resistance.

To provide more consistent support for the entomology personnel and activities in Zambézia, an entomologist and an entomology technician were hired by PMI and based in Quelimane. The entomologist, originally hired by PMI at the central level to support the national entomology surveys, has successfully transitioned to a MISAU/MOH/NMCP entomology position, bringing NMCP’s total staff to four persons. In addition, PMI continued to support entomologic strengthening at the central and provincial levels with training, supervision, and standardization of entomology techniques. PMI will also support an additional technician for the INS reference entomology laboratory to assist in the processing of mosquito samples from the national entomology surveillance activities, including mosquito material from the Zambézia IRS activities. The NMCP completed the National Entomology Monitoring and Evaluation Plan for 2012–2016, which includes insecticide resistance and residual efficacy testing for the IRS and LLIN programs and vector bionomics at sentinel entomologic sites. The number of entomologic sentinel sites and activities in the provinces will be scaled up from 2012 through 2016.

Table 1: Insecticide resistance test results of An. gambiae s.l. February 2015

<table>
<thead>
<tr>
<th>District</th>
<th>Anopheles species tested</th>
<th>Insecticide Tested</th>
<th>No. of replicates</th>
<th>No of mosquitos Tested</th>
<th>% Observed test mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mocuba</td>
<td>An. gambiae s.l.</td>
<td>Deltamethrin</td>
<td>12</td>
<td>300</td>
<td>74.33</td>
</tr>
<tr>
<td></td>
<td>An. gambiae s.l.</td>
<td>Lambdacyhalothrin</td>
<td>12</td>
<td>300</td>
<td>92.33</td>
</tr>
<tr>
<td></td>
<td>An. gambiae s.l.</td>
<td>Bendiocarb</td>
<td>4</td>
<td>100</td>
<td>98.9</td>
</tr>
<tr>
<td></td>
<td>An. gambiae s.l.</td>
<td>DDT</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>An. gambiae s.l.</td>
<td>Fenitrothion</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Morrumbala</td>
<td>An. gambiae s.l.</td>
<td>Deltamethrin</td>
<td>12</td>
<td>300</td>
<td>90.67</td>
</tr>
</tbody>
</table>
With the possibility of emerging insecticide resistance in Zambézia Province and the transition of certain IRS areas to universal LLIN coverage, epidemiologic and entomologic monitoring in IRS districts will be expanded. PMI is planning on expanding its support for the MISAU/MOH IRS program in such areas as guidance on training, supervision, and entomologic monitoring to areas outside of Zambézia Province.

Given widespread resistance to existing insecticides in most countries where PMI operates, it is imperative to ensure that the program expands the arsenal of insecticides for use in IRS. The pesticide chlorfenapyr, manufactured by BASF, is an insecticide from the pyroles class, and presents a possible short-term solution to vector resistance problems. Chlorfenapyr is not cross-resistant to DDT, pyrethroids, carbamates, or organophosphates. However, it is not yet recommended by WHOPES and cannot therefore be used for IRS by PMI.

### 3.7.3 DDT

The selection of DDT in Mozambique has been evidence-based, taking account of the susceptibility of *Anopheles arabiensis* (Patton), *An. funestus* (Giles) s.s., and *Anopheles gambiae* (Giles) s.s. to all the available insecticide choices, as well as relative costs of the insecticide and the logistical costs of spraying.

Beginning in late 2005, DDT was re-introduced when the Government of Mozambique withdrew its ban on DDT. DDT was used for one round of spraying/year in rural areas, and carbamate (bendiocarb) was used in two rounds/year in urban areas. Deltamethrin was used in towns where structures with finished or painted walls were found. Historically, IRS insecticides have been procured by MISAU/MOH for all spray operations in the country, with the southern provinces using DDT and carbamates, and the central and northern provinces using pyrethroids (ICON - lambda-cyhalothrin). The exception has been Zambézia Province, which up until 2009 also used DDT.

At the request of MISAU/MOH and with support from PMI, a multi-disciplinary team from the World Health Organization (WHO), Food and Agriculture Organization (FAO), and the Ministry of Health from Brazil, conducted an external assessment of the insecticide management system in five provinces (Maputo, Zambézia, Nampula, Sofala, and Gaza) in January and February 2008. This assessment was conducted due to concerns expressed by MISAU/MOH regarding the potential leakage of DDT outside of the public health sector. This assessment focused on the logistics, transportation, stock management, and warehousing of insecticides used for IRS, with particular emphasis on DDT. The assessment found

<table>
<thead>
<tr>
<th>District</th>
<th><strong>Anopheles species tested</strong></th>
<th><strong>Insecticide Tested</strong></th>
<th><strong>No. of replicates</strong></th>
<th><strong>No of mosquitos Tested</strong></th>
<th><strong>% Observed test mortality rate</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>An. gambiae</em> s.l.</td>
<td>Lambdacyhalothrin</td>
<td>4</td>
<td>100</td>
<td>68.75</td>
</tr>
<tr>
<td></td>
<td><em>An. gambiae</em> s.l.</td>
<td>Bendiocarb</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>An. gambiae</em> s.l.</td>
<td>DDT</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>An. gambiae</em> s.l.</td>
<td>Fenitrothion</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Milange</td>
<td><em>An. gambiae</em> s.l.</td>
<td>Deltamethrin</td>
<td>4</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
that, although leakage from warehouses in Zambézia was documented, the amount was considered relatively small. It did acknowledge the potential for leakage throughout all of the steps of the insecticide management system, however. This assessment, along with anecdotal reports from the agricultural industry of high levels of DDT in agricultural products, prompted MISAU/MOH in 2008 to reconsider further DDT purchases. Therefore, all spraying conducted in 2010 used pyrethroids, including in Zambézia Province.

However, based on annual resistance testing where pyrethroid and carbamate resistance has been documented, Mozambique decided to use DDT for the 2014 IRS campaign in 11 districts. Most of the districts were in southern Maputo province (Magude, Matutuine, Moamba, Namaacha). Other districts were in northern Maputo (Manhica), Gaza province (Chokwe, Guija), Tete Province (Moatize and Tete city), and Cabo Delgado (Metuge). While the NMCP had planned to cover Dondo in Sofala province, the district was unable to build evaporation tanks on time, therefore Dondo wasn’t sprayed at all that year.

**Mozambique DDT Infrastructure Assessment Report**

In November 2013, the South African Regional Network (SARN) convened a meeting in Johannesburg, South Africa to support the Mozambique NMCP to address the Global Fund (GF) requirements for the Mozambique Round 9 Phase II grant proposal. To meet GF requirements, an assessment of the IRS infrastructure for using DDT was conducted in March 2014 with the support of vector control experts from South Africa, Swaziland and Zimbabwe. The objective of the evaluation was to carry out an assessment of facilities, infrastructure, equipment and human resource needed for using DDT during the 2014-2015 IRS campaign in the selected target districts in Maputo, Gaza, Cabo Delgado and Tete, and recommend improvements as needed.

**Summary of Findings:**

In general, the evaluators determined that there are sufficient human resources to carry out the IRS operations at the district level (spray operators, etc.) but not at the national or provincial level (supervisors). The store facilities were adequate and fairly well maintained. Several districts have soak pits, but they are not always used according to the recommended PMI IRS BMPs (need to implement progressive rinse practices). In most districts, there were inadequate vehicles for transporting spray operators and supplies. Overall, there were many broken spray pumps that needed to be repaired. Also, pesticide sachet tracking was inadequate and the result could be a high potential for pilferage.

**Expired DDT supplies**

There were 15 boxes (670g X 20 per box) of expired DDT found in Namaacha District, Maputo Province (manufacturing date July 2010 and expiry date June 2012).

**Disposal of DDT solid and liquid wastes**

Thirty-four plastic drums with DDT rinse water and empty sachets awaiting disposal from the 2013-14 spray effort were being stored at the Namaacha storage facility. Also at the Xai Xai storage facility there were 70 plastic drums (210 litres each) containing DDT wastewater from the past two IRS seasons.

**Recommendations:**

The findings also suggest that the country currently does not have a suitable DDT solid waste disposal facility, hence the reason for expired stock of DDT and DDT wastewater awaiting proper disposal. It is strongly recommended that the progressive rinsing method be used so that little or no DDT wastewater will need to be disposed of.
An incinerator to be used for the disposal of DDT solids wastes at the end of the spray round should be given careful thought. The country does not currently have an incinerator that meets the IRS requirements for incinerating empty DDT sachets. The NMCP in coordination with the Ministry of Agriculture and Environment need to explore the option of using neighboring countries with suitable incinerating facilities like South Africa and Zimbabwe.

It is strongly recommended that every sachet of DDT be accounted for as per the Stockholm Convention. It is therefore recommended that sachets be numbered and recorded, as opposed to the numbering of boxes, and should be initiated at the central store room and proceed through the provincial, district and village storerooms. This tracking system should be closely monitored and include monthly inspections. This would be in addition to the daily supervision work by the field officers and supervisors.

The evaluation team recommended that the disposal of DDT solid wastes should be the responsibility of the supplier. The national Ministry of Health should make it clear in the tender specification that the successful bidder will be responsible for disposing the solid waste in an appropriate manner. Empty containers or sachets awaiting disposal should be kept in a special, secure area in the insecticide storeroom to ensure that they are not stolen and used for other purposes. Arrangements for transportation to the central point (storeroom) should be done by the NMCP. The supplier will then collect the waste from the central storeroom for final disposal.

Under the Pesticide Act, the Ministry of Agriculture approves the importation of the DDT into Mozambique. During the spray round the Ministry of Agriculture should provide assistance and supervisory support and monitoring to ensure that the pesticides used for IRS is not diverted into the local market through pilferage.

**Assessment of the 2014 Campaign by NMCP**

The NMCP is looking into ways to apply the rigor, tools and best practices of Zambézia to the remainder of the country. There have been several recent meetings with them on the importance of engaging both the Agriculture and Environment Ministries; particularly in the target districts where they use DDT.

**3.7.4 FAO PREVENTION AND DISPOSAL OF OBSOLETE PESTICIDES**

FAO’s Program on the Prevention and Disposal of Obsolete Pesticides is working to inform the world about the dangers of obsolete pesticide stocks. It collaborates with developing countries to prevent more obsolete pesticides from accumulating and assists them to dispose of their existing stockpiles. In 2012 Mozambique requested help from FAO to facilitate risk reduction of pesticides, including the proactive banning of Highly Hazardous Pesticides and the promotion of alternative solutions, under the leadership of the Ministry of Agriculture and in coordination with the Ministry for the Coordination of Environmental Affairs and the Ministry of Health.

The following three interlinked projects associated with pesticide risk reduction have or are taking place in Mozambique at present:

**UTF/MOZ/107/MOZ – Prevention and disposal of obsolete pesticides and associated wastes in Mozambique (EOD: 1 September 2012 - NTE: 30 August 2015)**
The project became operational in April 2013. Its main objectives include the following:

- Collect and dispose new obsolete stocks of pesticides in Mozambique
- Develop a strategy to avoid future accumulation
- Train national staff from the government institutions (plant protection services) on measures to better implement the available legislation
- Disposal of the buried pesticides at Lichinga Hospital
- Develop a communication strategy to prevent future accumulation and safe use of pesticides

**GCP/MOZ/100/GFF – Disposal of Persistent Organic Pesticides (POPs) and Obsolete Pesticides in Mozambique (EOD: March 2011 - NTE: February 2014)**

The targeted impact of this project was to reduce the risk to public health and the environment posed by poor pesticide management. The risk reduction was quantified using a project specific M&E system based on risk identification and characterization to establish a national risk profile or risk baseline before, during and after project implementation.

The project had three components: 1) Disposal of buried pesticides, contaminated soils and contaminated containers; 2) Improved pesticide life cycle management; 3) Project management and M&E.

Activities started in August 2011 with the establishment of a Program Management Unit (PMU) composed of a National Coordinator and a National Environment Manager, based at the Plant Protection Department of MINAGRI. A Steering Committee (SC) was created and an NGO identified to work as National Observer and to assess the impact of the project to the communities.

*Since its initiation in 2011, the following activities have been carried out:*

- A preliminary assessment of the soils suspected of having been contaminated with pesticides;
- PMU staff trained on the Pesticides Stocks Management (PSMS) and M&E;
- Formulation of practical guidelines for the implementation of the regulations on pesticides management;
- Contracting of National Observer NGO and training on project impact assessment at community level;
- Procurement of material and equipment for the intrusive site investigation;
- Contracting of National and International Consultants to elaborate the Pesticide Management Guidelines that will support the legislation;
- Intrusive Investigation of 15 contaminated sites to assess the contamination;
- A site visit to the central stores was conducted in order to assess the situation of the containers of pesticides collected and centralized during the previous phases of the project;
- The revision and updating of the Hazardous Waste Regulation started;
- PSMS training was conducted for the PMU staff;
- Guidelines for the management of pesticides to support pesticide legislation were prepared; and
- A workshop to improve the draft document on Guidelines for the Management of Pesticides to support pesticide legislation was held.

The project aimed to identify pesticides and pesticide use situations which can be considered highly hazardous under Mozambican conditions; elaborate a plan of action to reduce the risks posed by these highly hazardous pesticides; initiate implementation of priority risk reduction activities; review the results of priority reduction activities; and develop mid and longer-term policies, programs and projects to reduce the risk of highly hazardous pesticides.
4. DESCRIPTION OF PROPOSED AND ALTERNATIVE ACTIONS

This section describes the alternatives for malaria control that were considered in the preparation of this report, including those that were accepted or rejected. Alternatives considered include the following:

1. **Preferred action:** Establish annual IRS campaigns that spray pesticides of the pyrethroid, carbamate, organochlorine, and organophosphate classes in high-risk districts and sectors identified by the evaluation of criteria such as transmission rate, vector susceptibility, and residual effect, appropriate home and wall structure, and ecological/human health impacts.

2. **No action alternative:** This action would discontinue PMI support for IRS activities in Mozambique.

3. **Spraying in alternative geographic regions:** This alternative would use different criteria to select alternative districts and sectors to spray.

4. **Using alternative pesticides:** This alternative would consider pesticides other than those recommended by WHO.

5. **Alternative technologies:** This alternative would consider methods other than IRS to achieve the stated goals of reduction in malaria mortality and morbidity.

### 4.1 PROPOSED ACTION - INDOOR RESIDUAL SPRAYING

The preferred action is to implement an IRS program in selected communities, choosing among the pyrethroid, carbamate, organochlorine, and organophosphate classes, and chlorfenapyr, when recommended, considering current entomological, epidemiological, logistical, environmental, and economic conditions. The Safe Use Action Plan (SUAP, Chapter 8) and the Environmental Mitigation and Monitoring Plan (Annex A) will be followed to ensure environmental compliance and safe operations.

In keeping with the goals set forth in the Malaria Strategic Plan, PMI aims to:

- Support an integrated, evidence-based approach to IRS that results in a more cost-effective and efficient targeted strategy for the entire country;
- Support the development of an updated integrated malaria vector control strategy; and
- Strengthen the MOH-led IRS program.

### 4.1.1 PROPOSED ACTIVITIES WITH FY 2015 FUNDING:

In the 2015 spray campaign, The PMI AIRS Project will work with the Mozambican National Malaria Control Program (NMCP) and other stakeholders to achieve at least 85 percent spray coverage of the 440,579 targeted structures located in six districts (original and newly created). The MOH will donate approximately 3,000 kgs of deltamethrin to The PMI AIRS Project to be used in Quelimane, Milange and Molumbo. PMI will fund the procurement of 3,724 kgs of organophosphate to be used in Mocuba, Morrumbala and Derre as these districts showed pyrethroid resistance during the resistance tests conducted by Abt in early 2015. In addition to spraying, the project will carry out the following activities:

- Support training, capacity building, and advocacy at the national, regional, and district level as
a means to achieving IRS sustainability. This will include building the capacity of government, counterparts, and partners to undertake high-quality IRS. The AIRS Mozambique team will work towards increasing districts' and DPS's role in supervising IRS in 2015.

- The GoM will spray 21 districts in 2015; 10 will use pyrethroids and the remaining 11 will use DDT. Supporting the NMCP beyond Zambézia is limited in 2015 to providing the government with the updated BMP manual (being finalized in Portuguese), which will be utilized by the GoM in their training of SOPs, leaders and supervisors, so that they begin applying best practices of IRS during the campaign. Training for the implementation of AIRS IRS implementation tracking tools will be conducted before the 2016 spraying season.

- Provide regular monitoring and evaluation (M&E) for The PMI AIRS project.

- Carry out a logistics assessment in all districts and arrange all procurement, shipping, delivery, and storage of spray tanks, spare parts, insecticides, and personal protective equipment (PPE).

- Prepare and submit the 2015 Supplemental Environmental Assessment (SEA).

- Ensure safe and correct insecticide application, thus minimizing human and environmental exposure to IRS insecticides, in compliance with the Safer Use Action Plan in the 2015 SEA.

- Coordinate information, education, and communication (IEC) and behavior change communication (BCC) sensitization and mobilization activities with other stakeholders to raise community awareness of IRS, and to encourage beneficiary and stakeholder ownership.

- Conduct routine entomological monitoring in all spray sites including assessing malaria vector density and species composition in intervention areas; establishing vector feeding time and location; monitoring the quality of insecticide application and insecticide decay rates; and assessing vector susceptibility and mechanisms of resistance.

- Conduct enhanced surveillance activities in selected health facilities in order to evaluate the impact of IRS.

- Promote cost efficiency through due diligence and efficiency of operations.

- Small Studies or Hut Trials - To expand on PMI IRS Entomological Monitoring, the PMI IRS program may conduct small studies or hut trials to study new IRS insecticides such as chlorfenapyr; once the insecticide has been submitted for Phase III WHOPES evaluation and country-level required documentation has been submitted. The guidelines for laboratory testing and small and large-scale field trials are provided in Test procedures for insecticide resistance monitoring in malaria vector mosquitoes (WHO, April 2013).

- In order to test chlorfenapyr in Mozambique, the pesticide must be registered in country, and an approval letter to conduct an efficacy field trial may be required from MINAGRI or MISAU/MOH.

### 4.2 NO PROJECT ALTERNATIVE

Indoor Residual Spraying is one of the critical interventions in the control of the spread of malaria. A no project alternative will result in rising rates of infections, transmissions, mortality and morbidity due to the increased prevalence of infected vectors. Therefore, the no action alternative does not meet the overall goal of the Mozambique National Malaria Control Program and President's Malaria Initiative, which is to reduce malaria morbidity and mortality.
4.3 ALTERNATIVE IRS GEOGRAPHICAL SITES

Zambézia Province continues to have the highest prevalence of malaria in Mozambique as shown in the 2011 DHS, necessitating continued investment in this province. The recent 2011 Demographic and Health Survey (DHS) data show that malaria prevalence, using rapid diagnostic tests (RDTs), varies from 1.5% in the capital, Maputo, to 54.8% in Zambézia Province. Prevalence rates are generally higher in the northern region, varying from 43.3% to 52.1%, and lower in the southern region, varying from 1.5% to 36.8%. In the central region, the prevalence varies from 30% to 37%, except for Zambézia with 54.8%. The prevalence in rural areas is almost three times as high as the prevalence in urban areas, 46% versus 16%, respectively.

The Malaria Acceleration Plan 2014–2016, which is a multi-year operational plan of the malaria control strategy, and the Global Fund NFM concept note call for a scale-up of LLIN distribution and a more targeted approach for IRS. As a result, districts that were formerly targeted to just receive IRS are now also slated to receive universal LLIN coverage. An integrated vector control strategy was drafted in 2013 that laid out criteria for selecting IRS areas (high malaria burden, high economic interest, high population but not highly urbanized centers, etc.), leading to the selection of 34 target districts nationwide. However, it did not take into account plans for universal coverage of LLINs in former “IRS districts.” Therefore, within the next year, with PMI support, the NMCP will be working to draft a new malaria vector control strategy that prioritizes insecticide resistance management and malaria burden reduction. PMI will establish a provincial-level platform for BCC, MIP interventions, M&E, and case management beginning with funding in four provinces (Nampula, Cabo Delgado, Zambézia, and a fourth Tete). These provinces have been selected because of their high burden of malaria and the presence of strong local partners. In provinces where the USG has existing partners, efforts will be made to use these existing mechanisms, thereby following the GHI mandate and avoiding duplication of efforts.

4.4 USE OF ALTERNATIVE INSECTICIDE(S)

For IRS to be supported by PMI, a pesticide approved by World Health Organizations (WHO) under the World Health Organization Pesticide Evaluation Scheme (WHOPES) must be selected for use. WHOPES is the institution that analyses and recommends the pesticides that should be used in IRS based on their effectiveness, cost, and toxicity to human health and the environment.

To date WHOPES has approved the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines and organophosphates. When chlorfenapyr is WHPOES-approved, it will be available for IRS use. Currently, there are no other pesticides eligible for use in PMI-sponsored IRS, so deliberations were confined to the WHO-approved pesticides. This proposed action for Mozambique includes the use of organophosphates, carbamates, DDT, chlorfenapyr (when recommended), and pyrethroid formulations.

4.5 ALTERNATIVE TECHNOLOGIES

A full range of known, available technologies is continually considered for use by the stakeholders in malaria prevention and control efforts. It has been determined that IRS plays a significant part in malaria prevention in concert with those other technologies. The specific focus of this PMI effort and the role

11 PRESIDENT’S MALARIA INITIATIVE Malaria Operational Plan (MOP) Mozambique FY 2013
that PMI plays in Mozambique includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays, the National Malaria Control Program, PMI and its partners would evaluate them and proceed accordingly.

The NMCP malaria prevention plan incorporates Integrated Vector Management (IVM) using various vector control interventions, which are selected on the basis of the local factors that determine malaria transmission. Environmental management/larval control is an IVM intervention that includes all physical, chemical and biological methods. Larval mosquito vector control of malaria has the potential to be effective whenever the breeding targets are well defined and are limited in number, particularly in the sub and peri-urban areas. Currently, larval control and the reduction of potential breeding grounds are not common practices, and only are implemented in specific geographic locations. To be successful, this activity requires multi-sectoral and community involvement.
5. AFFECTED ENVIRONMENT

5.1 COUNTRY OVERVIEW

Mozambique is located on the east coast of southern Africa on the Indian Ocean, between latitudes 10°27'S and 26°52'S and longitudes 30°12'W and 40°51'W. The country is bordered by the United Republic of Tanzania in the north, South Africa in the south, Swaziland in the southwest and South Africa, Zimbabwe, Zambia in the west, and Malawi in the northwest. The country has a total area of 801,590 km², of which 2 percent are inland waters. The country is about 1,750 km long and its maximum width is about 1,100 km. The land borders have a length of 4,445 km, while the coastline measures 2,515 km.

Figure 1: Map of Mozambique
5.2 CLIMATE

Mozambique lies largely within the tropics, and much of the coastline is subject to the regular seasonal influence of the Indian Ocean monsoon rains. The monsoon influence is strongest in the northeast but is modified somewhat in the south by the island barriers of Madagascar, the Comoros, and the Seychelles. With the exception of highland areas on the northern and western borders and around Gurue (east of the Malawi protrusion into Mozambique), where elevation modifies both temperature and humidity, the climate is seasonal and tropical. Daily temperatures throughout the country average in the lower to mid-20s °C, with the highest temperatures occurring between October and February and the lowest in June and July. Uncomfortably warm average daily temperatures in the low 30s °C are normal only in the upper Zambezi valley and along the northeastern coast, while cool temperatures in the 10s °C occur year-round only in the mountainous areas on the western borders.

Humidity and precipitation vary widely throughout the country. Again, the sharpest contrast is between north and south. The entire region north of the Zambezi and east of the Shire River valley is humid and warm, as is the coastal plain in the south, while the southern interior and most of the Zambezi valley west of the Shire are quite dry; the south-central area is even considered semiarid. Precipitation is greatest throughout the north and in the central region east of the Shire River, where it ranges between 1,000 and 1,800 mm; the highest precipitation, averaging more than 1,800 mm, is in the highlands and in coastal pockets around Beira and Quelimane. In the Zambezi valley west of the Shire, however, average precipitation declines to between 600 and 800 mm, whereas in the south, to the west of the coastal plain, average annual precipitation is only about 600 mm. The semiarid southern regions receive only about 75 mm of precipitation per month in the wet season from November to February and almost none in the dry season between April and October. As the annual precipitation figures suggest, west-central and southern Mozambique are subject to periodic drought.12

5.3 TOPOGRAPHY

There are three basic geographic divisions:

- A coastal belt which covers about 44 percent of the country, comprising most of the areas south of the Save River and the lower Zambezi area;
- A middle plateau, ranging from 200 – 1,000 m in elevation and covering about 29 percent of the country;
- A plateau and highland region with average elevations of around 1,000 m to the north of the Zambezi River covering about 27 percent of the country.

Lowlands dominate the southern provinces, narrowing to a mere coastal plain north of the cleft where the Zambezi River cuts through the country’s midsection. The Zambezi valley, the lower section of which is a part of the Eastern (Great) Rift Valley, is Mozambique’s most dramatic geographic feature. Throughout the country the land rises gently from east to west. In the center and north it slopes steadily into the high plains and ultimately to the mountainous regions on the northwest border with Malawi and Zambia. Four of Mozambique’s five highland regions straddle the west and northwest border areas: the Chimoio Plateau on the border with Zimbabwe, the Marâvia highlands bordering Zambia, and the Angónia highlands and Lichinga Plateau, which lie, respectively, west and east of Malawi’s protrusion into Mozambique. Mount Binga, the country’s highest elevation at 2,436 m, is part of the Chimoio highlands. The 2,419 m peak at Mount Namúli dominates the Mozambican highland, which constitutes much of the northern interior.

12 http://www.britannica.com/EBchecked/topic/395363/Mozambique
5.4 **SOILS**

Africa’s ancient basement complex of granite rock underlies most of northern and west-central Mozambique, whereas the soils of the southern and east-central regions are sedimentary. Mozambique’s soils are diverse in quality and type, but the northern and central provinces have generally more fertile, water-retentive soils than does the south, where sandy, infertile soils prevail. The northern soils, whose qualities allow agricultural potential to extend beyond the river valleys, have a higher content of red clay, with a varying range of fertility. In contrast, the central region has a broad expanse of rich alluvial soils along the Zambezi delta. South of Beira, fertility is largely limited to alluvial soils in the valleys of the Save, Limpopo, Incomáti, Umbeluzi, and Maputo rivers, although several pockets of fertile but heavy soil occur southwest of Inhambane.

5.5 **HYDROLOGY**

Mozambique’s ample water resources have the potential to compensate for the mixed quality of its soils. Major river systems provide alluvial deposits and offer both hydroelectric and irrigation potential. The Rovuma (Ruvuma) River defines most of Mozambique’s northern border with Tanzania. The Zambezi River and its tributaries dominate the central region, and the Maputo River forms part of the southernmost boundary with Swaziland and South Africa. Rivers, including the Lúrio, Ligonha, Save
(Sabi), Changane, and Incomáti (Komati), also define many of the country’s local political boundaries. Other important drainage systems include the Messalo River in the north, the Pungoë (Pungué), Revuè, and Büzi rivers, which enter the Mozambique Channel together just south of the port of Beira, and the Limpopo River in the south.

The massive Zambezi flows 819 km through the country and drains more than 225,000 km² of the central region. The Rovuma, Lúrio, Save, and Messalo systems follow in size, respectively.

Mozambique has 104 identified river basins that drain the central African highland plateau into the Indian Ocean. The majority of the rivers have a highly seasonal, torrential flow regime, with high waters during 3-4 months and low flows for the remainder of the year, corresponding to the distinct wet and dry seasons.

Groundwater potential is considerable and lies in the alluvial formations of the various rivers. Well yields in the Zambezi and Incomati basins are up to 70,000 m³/day.

The two main lakes are Lake Niassa (Lake Malawi) and Lake Chirua (Lake Chilwa), both of which are shared with Malawi. The total surface area of Lake Niassa is 30,800 km², of which 21 percent belongs to Mozambique. Lake Chirua has an average total area of 750 km² of which no more than 29 km² are within Mozambique. In addition to the two main lakes, there are more than 1,300 small lakes, 20 of which have an area of between 10 and 100 km².¹³

### 5.6 Vegetation

About 62 million ha, or 78 percent of the total area, are covered by natural vegetation, consisting of high forest (0.8 percent), low forest (13.8 percent), thicket (43.4 percent), wooded grasslands (19.5 percent) and mangroves (0.5 percent). The total cultivable land is estimated at 36 million ha, which is 45 percent of the total area of the country.

Natural vegetation varies from evergreen to deciduous, from mountainous, to lowland, gallery and mangrove forest and from forest to edaphic grass. The majority of forest is open broadleaved forest, with Brachystegia spp. most common, especially in the north and center of the country. Closed broadleaved forests are primarily montane or submontane forests, riverine forests or mangroves. Significant areas of savannah and scrubland also occur. For example, Colophospermum mopane savannah-type forest is dominant over extensive areas. The country has a relatively extensive protected areas network with around 10 percent of the country’s forests in protected areas.

Although Mozambique retains some dense forests in the north-central interior and on the Chimoio Plateau, most of the northern and east-central areas are open forest. In the south the open forest of the east becomes brush and, to the west, savanna grassland. The largest forest reserves are on the Chimoio Plateau west and southwest of Beira and in the northern interior south of the Lúrio River.

Thick forest covers the wet regions, where there are fertile soils, but the drier interior, which has sandy or rocky soils, supports only a thin savannah vegetation. Extensive stands of hardwood, such as ebony, flourish throughout the country. Wood production is from natural forests and is almost entirely consumed by the local rural populations for fuel and construction.

The forestry sector has an important role in the country, contributing four percent of gross domestic product and supplying about 80 percent of the energy used. The country produces moderate volumes of mainly non-coniferous sawn timber. Important non-wood forest products in Mozambique include bushmeat, grass, bamboo, reed, medicinal plants, and a variety of wild edible plants. Mozambique has established a modest area of plantations (50,000 ha) based on Pinus, Eucalyptus and Casuarina species. Industrial plantations are mainly located in Manica Province, where they were established in the early 1980s. Non-industrial plantations are located near three urban areas: Maputo, Beira and Nampula. In addition, Casuarina spp. are planted to control coastal sand dune movement.

5.7 AGRICULTURE

Mozambique has a variety of regional cropping patterns; agro-climatic zones range from arid and semi-arid (mostly in the south and south-west) to the sub-humid zones (mostly in the center and the north) to the humid highlands (mostly the central provinces). The most fertile areas are in the northern and central provinces, which have high agro-ecological potential and generally produce agricultural surpluses. Southern provinces have poorer soils and scarce rainfall, and are subject to recurrent droughts and floods.

With the large majority of agricultural production being rain-fed, weather variability is a major factor in determining crop performance. The main growing season starts with the first rains in September in the south and December in the north. There is also a minor growing season, based on residual soil moisture, from March to July, accounting for approximately 10 percent of total output.

Agriculture is for the most part based on small, hand-cultivated units often farmed by women-headed households. About 97 percent of production comes from some 3.2 million subsistence farms averaging 1.2 hectares. The smallholder sector in Mozambique is characterized by holdings of multiple small plots, multiple crops, rain-fed water, traditional varieties, low intensity fertilizer and pesticide use and little or no mechanization, and low productivity. Most households diversify to cope with low productivity and income. The majority practice extensive shifting cultivation, only about one-third sell any crop output, and almost two-thirds live in households that lack food security.

There are about 36 million hectares of arable land, suitable for agriculture. At present, only 3.9 million hectares, which make about 10% of the arable land, are under cultivation. The remainder of the area is under pastures (44 million ha) and forest / woodlands (30.7 million ha). About 118,000 hectares are equipped for irrigation, covering 3% of the potential land.

Food crop production is the most important agriculture sub-sector accounting for around 80 percent of the cultivated area (2009). Maize and cassava are the major staples; other food crops include sorghum, millet, rice, beans, groundnut, sweet potatoes and a wide variety of vegetables. Maize is grown in all regions of the country by about 79 percent of rural households and occupies about 35 percent of total planted area. Cassava is grown mainly in the north and southeast, where it is the main staple. This crop is an important component of the smallholder’s risk reduction strategy because it is drought tolerant and resistant to disease. Groundnut is cultivated on sandy soils in most locations and makes an important contribution to household diet and income. The main cash crops are tobacco, cotton, sesame, sugar and tea. Tree crops, especially coconut and cashew, grown by small farmers, are an important source of foreign exchange earnings, and contribute to household food security.

5.8 LIVESTOCK

Animal husbandry is an underdeveloped sector. Cattle, goats, sheep and pigs are reared in extensive grass-based (ruminants) or back-yard scavenger systems. There is also a small fast-growing modern poultry industry. In 2009, livestock accounted for 1.2 million of head of cattle, 4.5 million sheep and goats, 1.3 million pigs, and 18 million poultry. The southern region is the heart of livestock activities
because animals there are less prone to diseases.

The principal form of livestock in Mozambique is cattle, which are raised traditionally in an extensive manner on natural pastures. Most of the national herd is concentrated in the relatively tsetse-free southern fifth of the country south of the Rio Save. Although concentrated, the cattle numbers are not so high as to cause large areas to be overgrazed. This is partly due to the reasonable rainfall and productive pastures of much of the zone.

5.9 FISHERIES

Most fishing in Mozambique is ocean-fishing, along the central coast of the country, rather than from inland, fresh-water fishing. In the fisheries sub-sector, some 1,500 species are believed to live in the Mozambican seawaters, of which 400 are of commercial importance. Three are three main types:

- **Industrial fishing with large ships:** Mozambique allows fishing companies from other countries like Japan and Spain to ply its waters. Much of the large-scale fishing is for export to other countries.

- **Semi-industrial fishing with medium sized boats (between 10m and 20m long):** Many of these boats are for catching shrimp by trawling, or they are line-catch fish. The majority of the fishing companies that catch and sell fish domestically don't have new boats and equipment so it's more difficult to compete internationally.

- **Artisanal fishing with small boats:** There are many communities in Mozambique where people fish in small groups or by themselves. Some of the fish they catch is for their own consumption, and some of it is for sale. 14

Aquaculture in Mozambique is a relatively new activity. The culture of freshwater species such as tilapia has existed for many decades (since the 1950s), whereas the cultivation of marine species has emerged over the last five years. The aquaculture industry in 2003 consisted of commercial farms producing marine shrimp (*Penaeus* spp.) and seaweed (*Kappaphycus* spp.), and artisanal farms producing tilapia (*Tilapia* spp.).

It is estimated that there are over 3,500 freshwater fishponds (200-400 m² in area, 105 ha) in Manica, Niassa, Tete, Sofala and Zambézia.

There are currently three commercial shrimp aquaculture enterprises operating in Beira, Sofala Province (Sol & Mar with 500 ha), Quelimane, Zambézia province (Aquapesca with 1,000 ha) and Pemba, in Cabo Delgado province (Indian Ocean Aquaculture with 980 ha). All use a semi-intensive farming system in earthen ponds (size range from 5-10 ha). The species produced are *Penaeus monodon* the giant tiger prawn and *Penaeus indicus* the Indian white prawn.

Seaweed (*Eucheuma spinosum* and *Kappaphycus alvarezii*) is farmed in Cabo Delgado (from Pemba to Macomia, including some islands in the Quirimba archipelago) and in Nampula (between Angoche and Nacala) provinces.

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5.10 **DEMOGRAPHICS**

The total population is estimated at 25,303,113 in 2015, with a population growth rate of 2.45 percent. In 1987, the government embarked on a series of macroeconomic reforms designed to stabilize the economy. These steps, combined with donor assistance and with political stability since the multi-party elections in 1994, propelled the country’s GDP from $4 billion in 1993, following the war, to about $30.9 billion in 2014. Fiscal reforms, including the introduction of a value-added tax and reform of the customs service, have improved the government's revenue collection abilities. In spite of these gains, more than half the population remains below the poverty line. Subsistence agriculture continues to employ the vast majority of the country's work force. On average households in Mozambique have 4.4 people with 69% headed by men and 31% by women. Urbanization in Mozambique has not proceeded as quickly as in many other countries; 32% of the population is urban and 68% live in the countryside. The most populous province is Nampula with almost four million inhabitants, followed by Zambezia, with 3.8 million. Tete is now the third largest province with 1.8 million inhabitants - 8.8 per cent of the total. The central province of Manica has also seen its population grow more rapidly than the average rate and now has 1.4 million inhabitants, or seven per cent of the total. The population is overwhelmingly young. 45% of Mozambicans are less than 15 years old. 51% per cent are aged between 15 and 64, and only 2.9% are aged 65 and above.\(^{15,16}\)

During Portuguese colonial rule, a large minority of people of Portuguese descent lived permanently in almost all areas of the country, and Mozambicans with Portuguese blood at the time of independence numbered about 360,000. Many of these left the country after independence from Portugal in 1975.

5.11 **HEALTH**

After its independence from Portugal in 1975, the Mozambique government established a primary health care system that was cited by the WHO as a model for other developing countries. Over 90% of the population had been provided with vaccination. During the period of the early 1980s, around 11% of the government budget was targeted on health care. The Mozambique civil war led to a great setback in the primary health system in Mozambique. The RENAMO's attack on government infrastructures included health and education systems from 1980 to 1992.

Health services in Mozambique are provided at the primary level by health posts (652) and health centers (435); rural hospitals (27) and district hospitals (8) at the secondary level; general (5) and provincial hospitals (7) at the tertiary level and at the quaternary level by central hospitals (3). This is equivalent to one health unit per 15,000 inhabitants with only 40% of the population having access to these health facilities. The remainder of the population is covered by: traditional medicine, community health agents, elementary agents and traditional birth attendants. A small part of the population is covered by private healthcare, mainly concentrated in the big cities. The main health challenges in Mozambique remain communicable diseases. HIV/AIDS is now responsible for 1 in 3 deaths and the death rate due to malaria in children under 5 equivalent to 1,159/100,000 population.\(^{17}\)

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\(^{17}\) [http://www.access2insulin.org/mozambiques-health-system.html](http://www.access2insulin.org/mozambiques-health-system.html)
Districts have an average of 14 primary-level facilities, of which 7 are health centers and health posts and the remainder are community posts. There are, however, notable differences across districts in the number of community posts, with some districts having many and many districts having none.  

The fertility rate is at about 5.5 births per woman. In the early 21st century there were 3 physicians per 100,000 people in the country. Infant mortality was at 100 per 1,000 births in 2005. The 2010 maternal mortality rate per 100,000 births for Mozambique was 550. The under 5 mortality rate, per 1,000 births was 147 and the neonatal mortality as a percentage of under 5 mortality was 29.

5.12 Education

Education in Mozambique is organized by three main stages: primary education, secondary education and higher education. By 2013, the literacy rate was 48%. The largest and oldest university is the Eduardo Mondlane University in Maputo, founded in 1962. Although having a national public education system, several educational programs and initiatives in Mozambique are mainly funded and supported by the international community. According to USAID, as of 2009 Mozambique still lacked sufficient schools and teachers to guarantee education for the nation's youth. An estimated 60% of adults still couldn’t read and write, with the illiteracy rate higher among women.

Since independence from Portugal in 1975, school construction and teacher-training enrollments have not kept up with population increases. Especially after the Mozambican Civil War (1977–1992), with post-war enrollments reaching all-time highs due to stability and youth population growth, the quality of education has suffered. All Mozambicans are required by law to attend school through the primary level; however, a lot of children in Mozambique do not go to primary school because they have to work for their families' subsistence farms for a living. In 2007, one million children still did not go to school, most of them from poor rural families, and almost half of all teachers in Mozambique were still unqualified.

5.13 Infrastructure

Infrastructure in Mozambique is generally poor and inadequate, especially in the many areas heavily affected by the war. The country has approximately 30,400 kilometers of highways, 5,685 kilometers of which are paved. Large sections of the remaining 24,175 kilometers of highway are virtually impassable during the rainy season. In addition to the road network, there is a total of 3,131 kilometers of railway, as well as 170 airports, although only 22 have paved runways (est. 1996). Major rail lines connect to South Africa, Malawi, and Zimbabwe.

5.14 Mozambique Provinces

Mozambique is divided into ten provinces and one capital city with provincial status (a description of the provinces including the city of Maputo are provided below). The provinces are subdivided into districts. The districts are further divided in Postos Administrativos and then into Localidades, the lowest geographical level of the central state administration. Since 1998, 53 Municípios have been created in Mozambique. The ten provinces include the following:

- Niassa Province
- Cabo Delgado Province
- Nampula Province

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18 The World Bank. Primary Health Care in Mozambique. April 2004
5.14.1 **Niassa Province**

Niassa Province has an area of 129,056 km² and a population of 1,213,400 (2007). It is the most sparsely populated province in the country. Lichinga is the capital of the province. There are an estimated 450,000 Yao people living in Mozambique who largely occupy the eastern and northern part of the province.

The Ruvuma River forms much of the northern boundary of the province with Tanzania while Lake Niassa forms the western border of the province, separating it from Malawi. 75% of the province...
remains untouched by development. The province shares the Niassa National Reserve with neighboring Cabo Delgado Province.

The main language spoken in Niassa is Makua at 43.6 percent, followed by Yao (37.2 percent), and Nyanja (10 percent).

As expected from an overwhelmingly rural province, the great majority of the economically active population (83.4 percent) work in the primary sector (agriculture, forestry, fishing and mining). Manufacturing industry and construction accounts for just 3.5 per cent, while the remaining 13.1 per cent work in transport, trade, finance and other services.

5.14.2 Cabo Delgado Province

Cabo Delgado is the northernmost province of Mozambique. It has an area of 77,867 km² and a population of 1,634,200 (2007). As well as bordering the neighboring country of Tanzania, it borders the provinces of Nampula and Niassa. The region is an ethnic stronghold of the Makonde tribe. Macua and Mwani ethnic groups are also present. Pemba is the capital of the province; other important cities include Montepuez and Mocimboa da Praia.

The population is overwhelmingly rural, with only 8.6% residing in Pemba.

The three languages that the respondents said they most often spoke at home are Makua (67.4 percent), Makonde (19.7 percent) and Kimwani (6.3 percent).

As is only to be expected in a rural society, the vast majority (87.4 percent) of the economically active population work in the primary sector (agriculture, fishing, forestry and mining). A mere 3.2 per cent work in the secondary sector (industry and construction), while the remaining 9.4 per cent work in transport, finance and other services.

5.14.3 Nampula Province

Nampula Province is in northern eastern Mozambique. It has an area of 79,010 km² and is the most populous province with a population of 4,084,700 (2007). Nampula is the capital of the province. It is bordered on the north by Cabo Delgado Province and the Lúrio River, which the Mozambican government has plans to build a 120-megawatt hydroelectric plant on to supply electricity to the province and Cabo Delgado Province. Nampula Province borders Niassa Province to the northwest and west, Zambezia Province to the southwest, and the Indian Ocean to the east. The Ligonha River separates it from Zambezia Province; the Makua peoples inhabit the area to the north of the river. From the south, the Malema River flows from the Namuli hills into the Ligonha. The Meluli River flows down through the province in a southeasterly direction, flowing into the Indian Ocean to the south of Angoche Island.

To the west of the city of Nampula, which lies in the heart of the province, are several hilly areas. Mountains in the province include Mount Ribaue, Mount Panda and Mount Nairucu.

Nampula is an overwhelmingly agricultural province with 83.4 percent of the economically active population working in the primary sector (agriculture, forestry, fishing and mining). Only four percent work in manufacturing and construction, while the remaining 12.6 percent work in trade, transport, banking and other services.

5.14.4 Tete Province

Tete Province has an area of 98,417 km² and a population of 1,879,700 (2007). Tete is the capital of the province. The Cahora Bassa Dam is situated in this province. The main language spoken is Nyanja, with 46.5 percent giving it as their mother tongue, followed by Nyungue (27.5 percent), and Sena (11.4 percent).
A large percentage (84.8 percent) of the economically active population in Tete work in the primary sector (agriculture, forestry, fishing and mining). This is overwhelmingly subsistence agriculture, since coal mining has yet to take off. Despite the presence of the Cahora Bassa dam, only 3.9 percent work in the secondary sector (manufacturing industry, energy and construction), while the remaining 11.1 percent work in transport, finance and other services.

The Tete Province is reported to host coal reserves of approximately 6.7 billion tons, of which 3 billion tons represent sub-economic or economic grades. The province is regarded geologically as the largest undiscovered coal province in the world and it is estimated that the Province could be producing 25 percent of the world’s coking coal by 2025. Moatize has enormous coal deposits and the main companies with coal concessions are Vale of Brazil and Riversdale of Australia.

The province is not highly urbanized with the most populous rural area being the fertile district of Angonia. The sharpest growth has been in Moatize district due to coal employment opportunities.

5.14.5 Zambezia Province

Zambezia Province is the second most-populous province of Mozambique, located in the central coastal region southwest of Nampula Province and northeast of Sofala Province. It has a population of 3,890,500 (2007). The provincial capital is Quelimane on the Bons Sinais River.

Zambezia has a total area of 103,478 km², much of it drained by the Zambezi River. Much of the coast consists of mangrove swamps, and there is considerable forest inland. The most common local language is Chuabo.

Agricultural products include rice, maize, cassava, cashews, sugarcane, coconuts, citrus, cotton, and tea; the country’s largest tea estates are at Gurúè. Fishing is especially productive of shrimp, and gemstones are mined at several sites.

5.14.6 Manica Province

Manica Province has an area of 62,272 km² and a population of 1,438,400 (2007). The province is surrounded by Zimbabwe in the west, Tete Province in the northwest, Sofala Province in the east, Save River in the south, and Zambezi river in the northeast. Chimoio is the capital of the province. The inhabitants practice subsistence farming. Main products are maize, cassava and goat meat. Agriculture is favored by the high rainfall and mild climate. Cashews were once an important export product. In 8th century the province came under the control of Munhumutapa Empire and had commercial relations with Arab-Swahili traders in the coastal regions. Later it came under the Portuguese influence. The highest mountain in Mozambique, Mount Binga (2436 m), lies in this province near the border with Zimbabwe.

Slightly more than half the population (50.3 percent) lives in the three districts - Gondola, Chimoio city and Manica - that lie along the Beira Corridor, the road and railway from the port of Beira to Zimbabwe.

The main languages spoken in the province are Nndau, given by 26.9 percent of respondents as their mother tongue, Chitewe (22.6 percent) and Sena (13.3 percent).

Manica is an overwhelmingly agricultural province, and so 71.3 percent of the economically active population works in the primary sector (agriculture, forestry, fishing and mining). Only 7.1 percent work in industry and construction, and the remaining 21.5 percent work in transport, finance and other services.
5.14.7 SOFALA PROVINCE

Sofala Province is in central-eastern Mozambique, cover an area of 68,019 km² has a population of 1,685,700 (2007). Beira is the capital of the province, named for the ruined port of Sofala, which is 35 kilometers to the south. The province is bordered to the north by Tete Province, to the northeast by Zambezia Province, to the south by Inhambane Province, and to the west by Manica Province. Rivers flowing through the province include the Chiveve River, the Buzi River, the Save River, which flows along the Inhambane provincial border, and the Púngué River, which flows into the sea at Beira. On the Urema River, a tributary of the Púngué, the river forms the lagoon, which are home to hundreds of hippopotamus. The valleys of the province are subject to flooding; in late January 2012, unusually heavy rain caused widespread flooding along the banks of the Púngué and the Save, and other major rivers in Africa such as the Zambezi and Limpopo, leading over 100,000 people in total to be evacuated.

The main language spoken in the province is Sena (49.1 percent), Ndau is the second most common language with 29.8 per cent giving it as their mother tongue.

Beira's influence in the province is clearly shown by the fact that only 36.1 percent of the economically active population work in the primary sector (agriculture, fisheries and mining), while 17.6 percent work in manufacturing and construction, and the remaining 44.8 percent work in transport, finance and other services. The great bulk of the province's industry and services is concentrated in Beira and along the line of rail from Beira towards Zimbabwe.

5.14.8 GAZA PROVINCE

Gaza Province has an area of 75,709 km² and a population of 1,236,300 (2007). Xai-Xai is the capital of the province. Inhambane Province is to the east, Manica Province to the north, Maputo Province to the south, South Africa to the west, and Zimbabwe to the northwest.

Most of the province lies in the basin of the Limpopo River, which runs from northwest to southeast through the district, emptying into the Indian Ocean near Xai-Xai. The Changane River, a tributary of the Limpopo, forms part of the province’s eastern boundary. The Rio dos Elefantes (Olifants River) flows into the district from the west through the Massingir Dam, to empty into the Limpopo. The Save River forms the northern boundary of the province.

The Limpopo railway, which connects Zimbabwe and Botswana to the port of Maputo, runs through the province, entering Zimbabwe at the border town of Chicalacuala.

The province, including the towns of Xai-Xai and Chokwe, were greatly affected by the 2000 Mozambique flood.

Gaza remains an overwhelmingly rural province. Only 9.5 percent of the population lives in the provincial capital, Xai-Xai. A large percentage (78.1 percent) of the labor force works in the primary sector (agriculture, fisheries, forestry and mining; there is very little mining or forestry in Gaza). Only 6.8 percent work in industry and construction, and the remaining 15 percent in services.

There is a long tradition of Gaza men emigrating to find work in South Africa, and this may have increased recently. One result is that the majority of Gaza households are headed by women - 50.2 percent, compared with 49.8 percent headed by men.

Gaza is the most ethnically homogenous province in the country with 87.2 % speaking of Xichangana.

5.14.9 INHAMBANE PROVINCE

Inhambane Province is located on the coast in the southern part of the country. It has an area of 68,615 km² and a population of 1,304,800 (2007). The provincial capital is also called Inhambane.

The town of Inhambane existed in the 10th century, and was the southernmost port used by Arabs for
slave trading. The region was visited by Vasco da Gama in 1498, who claimed Inhambane Bay for Portugal. The Portuguese established a trading post at Inhambane in 1534.

The province is the second largest grower of cashews (after Nampula), and also produces coconut and citrus fruit. The long coastline supports much fishing. The Inhambane Bay area is of some interest for tourism, with a number of beaches, and one of the last remaining populations of dugong in Mozambique.

The dominant languages in the province are Xitswa (55.7 percent) and Bitonga (23.6 percent).

As in Gaza, the overwhelming majority of Inhambane’s economically active population (79.2 percent) work in the primary sector (agriculture, forestry, fishing and mining). Only 5.8 percent work in industry or construction and the rest work in services.

A lot of people have been migrating out of Inhambane, particularly to Matola, the capital of Maputo province, and over the border into South Africa.

5.14.10 MAPUTO PROVINCE

Maputo Province excludes the city of Maputo (which comprises a separate province). The province has an area of 22,693 km² and a population of 1,225,500 (2007). Maputo Province is the southernmost province of Mozambique. It borders Gaza Province to the north, the Indian Ocean to the east, the South African province of KwaZulu-Natal to the south, Swaziland to the southeast, and the Mpumalanga province of South Africa to the west and northwest. The Maputo Bay area to the southeast of Maputo is an important conservation area with many reefs and lakes. The largest river of the province, the Maputo River flows into Maputo Bay to the southeast of Maputo. Also flowing into the bay are the Umbeluzi River and the Incomati River. In the fall of 1999, the Maputo, Umbeluzi, Incompati and Limpopo rivers were affected by severe rainfall, 70 percent higher than normal, which caused severe flooding.

To the north of the peninsula is the Inhaca Island (Ilha da Inhaca), a 52 km² subtropical island, about 12 km from north to south by 7 km from east to west which separates Maputo Bay to the west from the Indian Ocean off its eastern shores.

In the northwest of the province, near the South African border is a major reservoir and dam complex, the Corumana Dam, which dams the Sabie River.

5.14.11 CITY OF MAPUTO

Maputo is the capital and largest city of Mozambique. It is known as the City of Acacias, in reference to acacia trees commonly found along its avenues, and the Pearl of the Indian Ocean. Today, it is a port city on the Indian Ocean, with its economy centered on the harbor. According to the 2007 census, the population is 1,766,184. Cotton, sugar, chromite, sisal, copra, and hardwood are the chief exports. The city manufactures cement, pottery, furniture, shoes, and rubber. The city is surrounded by Maputo Province, but is administered as its own province.

Maputo is located on the west side of Maputo Bay, near the Estuário do Espírito Santo where the rivers Tembe, Umbeluzi, Matola and Infulene drain. The bay is 95 km long and 30 km wide. At the extreme east of the city and bay is the island of Inhaca. The total area covered by the municipality of Maputo is 346 km² and borders the city of Matola northeast and east, the districts of Marracuene to the north; Boane in the east and Matutuíne at the south all of which are part of Maputo Province. The city is 120 km from the South African border at Ressano Garcia and 80 km from the border with Swaziland near the town of Namaacha.
5.15 PROTECTED AREAS

5.15.1 NATIONAL PARKS

There are seven National Parks within Mozambique, which include the following:

- Banhine National Park - *Parque Nacional de Banhine* - Gaza (7,000 km²)
- Bazaruto National Park - *Parque Nacional do Bazaruto* - Inhambane (1,600 km²)
- Gorongosa National Park - *Parque Nacional da Gorongosa* - Sofala (5,370 km²)
- Limpopo National Park - *Parque Nacional do Limpopo* - Gaza (3,500 km²)
- Magoe National Park - *Parque Nacional do Magoe* - Gaza (10,000 km²)
- Quirimbas National Park - *Parque Nacional das Quirimbas* - Cabo Delgado (7,500 km²)
- Zinave National Park - *Parque Nacional do Zinave* - Inhambane (6,000 km²)

**Banhine National Park** is a protected area in the district of Chigubo, northern Gaza Province, Mozambique. The park was proclaimed on 26 June 1973. The park is 7,000 km² area and holds extensive inland wetlands, acting as an important source of water to the dry lands that surround it. The park is in an area that has annual rainfall of only 430 mm. However, over 1% of the park is wetland and there are also more than a thousand pans that range in size from a few square meters to hundreds of hectares. These pans may be very salty or "sweet" and drinkable. The water comes from the area to the northwest near the Zimbabwe boundary, flowing through many channels into the wetlands and then into the Changane River. Eighteen species of fish have been found in the park. The African lungfish, two killifish species and two Barbel species have developed ways to deal with predictable periods of drought. At times, the wetlands are completely dry on the surface. The Banhine National Park used to be home to buffalo, sable, tsetsebe, hartebeest, zebra, and wildebeest. Many of these animals were destroyed during the civil wars of the 1980s and early 1990s. However, the park is still home to endangered wattled cranes and to many migratory birds. Results of an aerial survey in October 2004 showed that the park had healthy populations of ostrich, kudu, impala, reedbuck, duiker, steenbok, porcupine, warthog and oribi.

The **Bazaruto National Park** (BANP) is a protected area in the Inhambane Province of Mozambique on the Bazaruto Archipelago. The park was proclaimed on 25 May 1971. It is off the coast of the Vilanculos and Inhassoro districts, covering a large expanse of ocean and six islands. The park was created to protect dugong and marine turtles, and their habitats. The islands' flora and fauna, coral reefs and marine birds were also included. The largest island is Bazaruto Island and the others are Benguerra, Margaruaque, Santa Carolina (Paradise Island), Banque and Pansy Shell Island. The islands have a lush tropical climate and include huge dunes, forest and savannah, inland lakes and wetlands. They host several endemic terrestrial gastropods and lizards. They also host important aggregations of Palaearctic migrant water birds. The archipelago is attractive to tourists who are interested in diving or snorkeling. The rich variety of marine life includes humpback whales, marine turtles, spinner, humpback and bottlenose dolphins, marlins and barracudas. BANP gives protection to the largest and only remaining viable population of dugongs in the Western Indian Ocean. The coral reefs are varied and said to be the least disturbed in this part of the Indian Ocean.

**Gorongosa National Park** is at the southern end of the Great African Rift Valley in the heart of central Mozambique. The over 4,000 km² park includes the valley floor and parts of surrounding plateaus. Rivers originating on nearby 1,863 m Mount Gorongosa water the plain. Seasonal flooding and waterlogging of the valley, which is composed of a mosaic of different soil types, creates a variety of distinct ecosystems. Grasslands are dotted with patches of acacia trees, savannah, dry forest on sands and seasonally rain-filled pans and termite hill thickets. The plateaus contain miombo and montane forests and a spectacular rain forest at the base of a series of limestone gorges. This combination of unique features at one time supported some of the densest wildlife populations in all of Africa, including
charismatic carnivores, herbivores and over 500 bird species. But large mammal numbers were reduced by as much as 95% and ecosystems stressed during Mozambique's long civil conflict.

**Limpopo National Park.** The 1,123,316 ha Parque Nacional do Limpopo (PNL) was formally a hunting zone (coutada) and was declared a National Park in November 2001. This enabled the creation of the Great Limpopo Transfrontier Park (GLTP) in December 2002 linking Kruger National Park (KNP) in South Africa, Gonarezhou National Park in Zimbabwe and Parque Nacional do Limpopo in Mozambique. PNL was officially opened to the public on 6th December 2005 when the Presidents of the three GLTP member countries opened the Giriyondo Border Gate between the Kruger National Park and the Parque Nacional do Limpopo. The western perimeter of PNL is formed by the border with South Africa and stretches in a north-south direction for a distance of nearly 200km. The Zimbabwean border touches on the most northerly tip of the area and then runs away in a northeasterly direction. The Limpopo River forms the eastern boundary, and the Elefantes River and Massingir Dam forms the southern boundary.

The Great Limpopo Transfrontier Park is an extensive area of essentially flat savanna bisected north/south by the Lebombo mountain range, and drained by four river systems flowing from west to east. Temperatures are mild in winter and very rarely drop below freezing point, while summers are hot with daily temperatures averaging in the thirties (centigrade). The area is generally rather dry with a rainy season in summer, average rainfall being about 550 mm per annum.

The **Magoe National Park** was proclaimed in October 2013. The 350,000 ha park is located on the southern banks of the giant Cahora Bassa dam. The park has been set aside as an oasis for wildlife in the northern Tete province where 60% of land has already reportedly been allocated to mining firms through concessions. Situated close to the Zimbabwe border, the park will protect hippos, elephants, lions, leopards and the rare roan antelope.

The **Quirimbas National Park (QNP)** is a protected area in the Cabo Delgado Province of Mozambique, encompassing the southern part of the Quirimbas Islands. The park was established in June 2002. It stretches for 110 km along the northeast coast of Mozambique, and contains the southernmost 11 of the Quirimbas islands. The park protects 750,639 ha of coastal forest, mangroves and coral reefs. The region was isolated for decades during the Mozambique civil war. On land, there are healthy populations of elephants, lions, leopards, crocodiles and even wild dog. Habitats include mountains, forests, woodland, savannah, mangroves, beaches, coral reefs and sea grass beds. The park contains a rich variety of marine life including sea turtles, dugongs and many species of fish. Three hundred and seventy-five species of fish have been identified, including threatened pipefish and seahorses.

The **Zinave National Park (PNZ)** is a protected area in Inhambane province, Mozambique, created by decree in June 1973. The park extends to the south of the Save River in Inhambane province, covering an area of 4,000 km². It was first proclaimed as a hunting area in 1962, and was promoted to a national park in 1972. The area represents a transition between the wet and dry tropical areas and has an annual rainfall of about 800 mm or less.

The highest elevation is on the southeast boundary at 174 m above sea level. The land slopes down in a north-northeasterly direction to its lowest elevation of 110 m at the Save River. The soil is mostly sandy, with clay soils from alluvial sediments along the Save River. Mean annual rainfall is 690 mm in the northeast, 571 mm in the west. There are seasonal pans scattered throughout the PNZ, some quite large. A 2010 report said that the PNZ had been neglected until recently, and most of its large wildlife had been destroyed by illegal hunting. Species that are locally extinct or close to extinct include black rhino, buffalo, cheetah, reedbuck, eland, elephant, giraffe, Lichtenstein Hartebeeste, roan antelope, sable antelope, spotted hyena, wildebeest and zebra. The park has very diverse tree species and at least 41 species of grasses.
5.15.2 National Reserves

Mozambique also has seven National Reserves, which include the following:

The **Gilé National Reserve** was first proclaimed as a partial hunting reserve in 1932. It is situated in the districts of Pebane and Gilé in the Zambézia province and covers an area of 2,100 km².

The **Maputo Special Reserve** (previously the Maputo Elephant Game Reserve) was proclaimed by Decree nº. 1994 of the 23rd July 1960. It is located in the Matatuine district, Maputo province and covers an area of 700 km².

The **Marromeu Game Reserve** is a protected swath of 10,000 km² of floodplain in the Zambezi, the only such area along the river. It was dedicated on 1 January 1969. It is located near Beira in the province of Sofala.

**Niassa Reserve** is a nature reserve in Cabo Delgado Province and Niassa Province, Mozambique. Covering over 42,000 km², it is the largest protected area in the country. The reserve is part of the Trans-Frontier Conservation Area and links to the Tanzanian Lukwika-Lumesule Game Reserve.
The **Pomene National Reserve** is the smallest conservation area in the country. Proclaimed by Decree 2496 of 4th of July 1964, it is situated in the district of Massinga in Inhambane province and covers an area of 200 km².

The **Chimanimani Nation Reserve** was created by Decree 34/2003 of 19th August 2000. It is situated in the province of Manica, district of Sussundenga the highest point in the country – Mount Binga 2454 m high on the border with Zimbabwe. It covers an area of 1000 km². The Chimanimani National Reserve (CNR) is situated in the Sussundenga district, Manica Province.

**Futi Corridor**, situated in Mozambique, it is a corridor of land along the Futi River to the South African border. The corridor will effectively restore an historical migration and movement route of a valuable elephant population between Maputo Special Reserve and the Tembe Elephant Park in South Africa. The Futi Corridor covers 68,800 ha. The reserve will eventually form part of the Lubombo Transfrontier Conservation Area.

### 5.15.3 Transfrontier Parks

A peace park/transfrontier park goes beyond political boundaries to accommodate gene pools, water flow, wildlife movement and propagation of plant species; an opportunity to unlock regional economic development, to share the conservation of biodiversity and to promote regional peace and stability by demonstrating the benefits of cooperation.

**Great Limpopo Transfrontier Park** is a 35,000 km² peace park that is in the process of being formed. It will link the **Limpopo National Park** (formerly known as Coutada 16) in Mozambique, Kruger National Park in South Africa, Gonarezhou National Park, Manjinji Pan Sanctuary and Malipati Safari Area in Zimbabwe, as well as the area between Kruger and Gonarezhou, the Sengwe communal land in Zimbabwe and the Makuleke region in South Africa.

The **Lubombo Transfrontier Conservation Area** covers 4,195 km² of which 2,783 km² (66%) is in Mozambique, 1,095 km² (26%) is in South Africa, and 317 km² (8%) is in Swaziland. It is situated on a low-lying coastal plain between the Lubombo Mountains in the west and the Indian Ocean in the east. The area offers a unique combination of big-game country, extensive wetlands, and beautiful undeveloped coastal areas. It links the **Maputo Elephant Reserve** in Mozambique through the **Futi Corridor** and the Lubombo Conservancy in Swaziland to the Tembe Elephant Park in South Africa, creating the first major elephant stronghold along Africa’s eastern coastline.

### 5.15.4 Wildlife Utilization Areas

Wildlife Utilization Areas in Mozambique allow hunting, ecotourism, ranching, trade and other uses. The following is a list of the utilization areas in Mozambique (no information is available for Coutadas 1-3):

- Coutada 4 - Manica (4,300 km²)
- Coutada 5 - Sofala (6,868 km²)
- Coutada 6 - Sofala (4,563 km²)
- Coutada 7 - Manica (5,408 km²)
- Coutada 8 - Sofala (310 km²)
- Coutada 9 - Manica (4,333 km²)
- Coutada 10 - Sofala (2,008 km²)
- Coutada 11 - Sofala (1,928 km²)
- Coutada 12 - Sofala (2,963 km²)
- Coutada 13 - Manica (5,683 km²)
- Coutada 14 - Sofala (1,353 km²)
- Coutada 15 - Sofala (2,300 km²)
- Coutada 16 - now part of the Limpopo National Park
5.16 ECOREGIONS

Figure 5: Map of Mozambique Ecoregions

Key to Ecoregion Map:
1) Southern Zanzibar-Inhambane Coastal Forest Mosaic
2) Eastern Miombo Woodlands
3) Zambezian and Mopane Woodlands
4) Zambezian Flooded Grasslands
5) (Southern Malawi Montane Forest-Grassland Mosaic – not in Mozambique)
6) (Southern Rift Montane Forest-Grassland Mosaic – not in Mozambique)
7) Southern Miombo Woodlands
8) Eastern Zambabwe Montane Forest-Grassland Mosaic
9) Zambezian Coastal Flooded Savanna
10) East African Mangroves
11) Zambezian halophytics
12) Maputaland Coastal Forest Mosaic
13) (Southern African Bushveld - not in Mozambique)

The following are descriptions of the ecoregions found in Mozambique, as identified by the World Wide Fund for Nature (WWF):

5.16.1 SOUTHERN ZANZIBAR-INHAMBANE COASTAL FOREST MOSAIC

Southern Zanzibar-Inhambane coastal forest mosaic is a tropical moist broadleaf forest ecoregion of eastern Africa. The ecoregion extends along the coast of Tanzania and Mozambique, from Tanzania's Lukuledi River south almost the whole way to the mouth of the Limpopo River to just south of Xai-Xai in Mozambique. The ecoregion is predominantly comprised of coastal forest mosaic within 50 km of the Indian Ocean, although it extents up to 200 km inland in the above mentioned outliers. It is also found on small offshore islands in Mozambique, including the Bazarruto Archipelago. The ecoregion supports habitats of forest, savanna and swamps. The area is in the rain shadow of Madagascar, hence it gets a smaller amount of rain than the Northern Zanzibar-Inhambane coastal forest mosaic.

Topographically, this ecoregion is a rolling landscape, with isolated higher plateaus and inselbergs, especially in the northern part of the ecoregion. To the south, sand dunes are an important feature, as they support coastal forest and thicket vegetation types.

The ecoregion is tropical in the northern portion and borders sub-tropical in the southern portion. Rainfall, controlled by monsoon winds, is around 800-1000 mm per year, although it is higher on some of the plateaus. Mean maximum temperatures are 30-27°C in the north and 24°C in the south of the ecoregion. Mean minimum temperatures are 18-15°C throughout the ecoregion. Mozambique Forest Department reports a number of 100 km² forest reserves that contain coastal forest. Further south in Mozambique the situation is much less known. Some areas probably never supported much forest, as the area is in the rainshadow of Madagascar and has 800 mm rainfall.

5.16.2 EASTERN MIOMBO WOODLANDS

The Eastern Miombo woodlands are an ecoregion of grassland and woodland in southern Tanzania and northern Mozambique. These species-rich savanna ecosystems cover wide areas of gentle hills and low valleys containing rivers and dambo wetlands. The region is located on the East African Plateau, extending from inland southeastern Tanzania to cover the northern half of Mozambique, with small areas in neighboring Malawi. The ecoregion covers an area of 483,900 km².

The region has a hot, tropical climate with a wet summer from November to March and a long winter drought. The woodlands are vulnerable to fire, particularly at the start of the summer.

This ecoregion is mostly confined to lower elevations of the East African Plateau, ranging from 200 m along the eastern coastal regions to 800 to 900 m in the interior. Several rivers traverse this area in a predominantly west-east direction; these include the Rio Ruvuma and Rio Lurio in northern Mozambique. Moderately undulating ridges mixed with shallow flat-bottomed valleys, or dambos that are often seasonally waterlogged characterize the landscape. Inselbergs are common, especially in northern Mozambique, rising noticeably above the uniform woodlands.

The ecoregion experiences a seasonal tropical climate with most rainfall concentrated in the hot summer months from November through March. This is followed by an intense winter drought that can last up to 6 months. Mean annual rainfall ranges between 800 and 1,200 mm, although peaks up to 1,400 mm per annum are found along the western margins. Mean maximum temperatures range between 21°C and 30°C depending on elevation, with the hottest temperatures experienced in the lowland areas.
The ecoregion’s mean minimum temperatures are between 15°C and 21°C, and the area is virtually frost-free.

The predominant tree is miombo (Brachystegia spp.), along with Baikiaea woodland. Despite the low rainfall and relatively nutrient-poor soil the woodland is home to many species. The miombo and other vegetation in and around the region have historically a variety of food and cover for several miombo specialist endemic bird and lizard species as well as more widespread mammals.

The protected areas of Niassa Reserve and Gile Nation Reserve are in this ecoregion.

5.16.3 ZAMBEZIAN AND MOPANE WOODLANDS

The Zambezian and Mopane woodlands is a tropical and subtropical grasslands, savannas, and shrublands ecoregion of southeastern Africa and is characterized by the Mopane tree (Colophospermum mopane) which is the sole canopy species throughout much of its range.). It is generally at a lower elevation, and has lower rainfall. Elevation and rainfall are the major environmental factors separating Zambezian and Mopane Woodlands from its three major neighboring ecoregions.

The ecoregion includes several of southern Africa’s major rivers, occupying the bulk of the Zambezi, Luangwa, Shire, and Limpopo River Valleys. Other regionally important rivers found within the Zambezian and mopane woodlands are the Save, Crocodile, and Nkomati Rivers.

Terrain is generally flat or gently undulating along the floors of the major river valleys, with average elevations ranging from 200 m to 600 m. Parts of the ecoregion may occur at slightly higher elevations in rolling or broken country above 760 m. The southeastern portion of the Zambezian and Mopane Woodlands occurs on the plains and foothills east of the Drakensberg escarpment, with elevation generally ranging from 170 m to 800 m, although heights of 1525 m are attained in places.

The flora of the Zambezian and Mopane Woodlands ecoregion is not characterized by high species diversity throughout its range. The mopane tree characterizes the entire ecoregion, and in many places dominates to the exclusion of other species, particularly trees.

This ecoregion is one of the most important areas for vertebrate diversity in southern Africa, particularly for mammals. Vegetation here is more nutritive than surrounding ecoregions with higher rainfall, and as a result, the area is well known for supporting large concentrations of ungulates.

The agricultural marginality of the Zambezian and Mopane Woodlands and the large attendant mammal populations have encouraged the establishment of an extensive protected area network in the ecoregion. The most significant national parks are Banhine, Gorongosa, and Zinave National Parks in Mozambique.

5.16.4 ZAMBEZIAN FLOODED GRASSLANDS

The Zambezian flooded grasslands can be found on seasonally or permanently flooded lowlands in the basin of the Zambezi and neighboring river basins. These enclaves lie in the broad belt of dry and not very fertile Miombo and Mopane savannas and woodlands that extend west to Tanzania and Mozambique in the east. The region has a tropical climate with a hot wet summer between November and March. These patches of wetland contain grassland and swamp vegetation which varies from area to area within this widely spread ecoregion. Unlike the surrounding woodlands that generally support animals only in rather low densities, the wetlands and floodplains of this ecoregion provide habitats to sizeable faunal populations, since food and water are abundant throughout most of the year. Large populations of waterbirds gather during the rainy season and numerous herd animals and carnivores still frequent the landscape.
Southern Miombo woodlands spills over into Mozambique from Zimbabwe on the eastern side of the Chimanimani Mountain Range northern Tete province. The remaining smaller segments are located in southern Mozambique, narrowly separated by the Rio Save. Most of the ecoregion is found on the Central African Plateau at elevations ranging between 1,000 and 1,500 m. The area is characterized by flat or undulating plains, intrusive granites and gneisses dominate geologically, and frequently rise up above the woodland as rounded hills (also known as dwalas) or inselbergs. Numerous grassy wetlands are interspersed along drainage lines in vleis or dambos.

Floristically, this ecoregion forms part of a wide belt of miombo woodland that stretches from Angola in the west to Tanzania in the east. Miombo plant communities are dominated by trees belonging to the family Caesalpiniaceae, and characterized by species in the genera *Brachystegia* and *Julbernardia*.

Miombo woodland mixes with mopane as well as smaller wetlands to provide habitat for a wide variety of animals, including endangered mammals such as African Elephant (*Loxodonta africana*) and Black Rhino (*Diceros bicornis*). The overall faunal diversity of this ecoregion is fairly high, as many of its species overlap with surrounding miombo and savanna ecoregions. Of the nearly 500 bird species found in the area, none are strictly endemic. However, six species are either largely confined to the ecoregion or have extremely small distribution ranges.

The ecoregion generally experiences a tropical savanna climate with three distinct seasons: a hot dry season from mid-August through October; a hot wet season from November through March; and a warm dry season from April through early August. Mean maximum temperatures are typically around 24°C. The ecoregion experiences mean minimum temperatures between 9°C and 15°C, and is virtually frost-free. Temperatures are considerably higher in the lowland areas of the ecoregion. Rainfall is highly seasonal, with a marked winter drought usually lasting from 4 to 7 months. The mean annual rainfall is around 600 to 800 mm in the main part of the ecoregion in Zimbabwe and increases to about 1,000 mm in the lower-elevation portion in Mozambique.

Mozambique, having suffered serious upheavals through years of civil war, does not presently have any effectively managed areas. Almost all wildlife was wiped out over the years for meat and to finance the war. However, management plans and efforts are beginning to be reapplied to Gorongosa National Park, a protected area that falls into the ecoregion.

The Eastern Zimbabwe montane forest-grassland mosaic ecoregion spans the border between Mozambique and Zimbabwe. These mountains consist of a complex mosaic of forests, woodlands, and grasslands that demonstrate strong floristic links to the surrounding areas of East and Southern Africa. The fauna also shows affinities to the mountains of these areas, although several endemic animals are found here as well. The characteristic rainy and foggy climate makes this region suitable for coffee, tea, and dairy farming as well as exotic timber plantations. However, the steep and largely inaccessible nature of these mountains has preserved native vegetation. A small isolated portion of the ecoregion is located in Mozambique at Mt. Gorongoza. The isolated Gorongoza Mountain in Mozambique rises to 1863 m.

This montane forest-grassland mosaic is wetter than the surrounding areas as a result of higher rainfall, characteristic low cloud cover, early morning mist and heavy dew. These conditions result from the higher topographic features forcing the predominant moist oceanic air masses from the southeast to rise and cool. Moisture held by the air condenses and falls as rain or forms low clouds from which forest vegetation can extract moisture through condensation. The annual rainfall in the ecoregion is highly variable, from 741 to 2997 mm per year. This variability is largely related to aspect, with east-facing slopes receiving higher rainfall than those facing west. Most of the precipitation occurs in the summer months from November to April, while the winter months from May to July are drier. From August
until the rains arrive in November, temperatures increase. It is during this time that extensive grass fires occur in the high-elevation grasslands. Frequent night frosts occur during the winter months, becoming heavier as elevation increases. The annual mean temperatures range from a minimum of 9° to 12° C to a maximum of 25° to 28° C.

The watersheds for two major rivers, the Zambezi River in the north and the Save River in the south, are located within the highlands making up this ecoregion. Rivers that originate in the highlands to the north of the ecoregion (such as the Gairezi and Inyangambe Rivers) meet the Zambezi River just past the town of Tete in Mozambique. The Zambezi then flows into the Indian Ocean on the Mozambique Coast. The highlands to the south of the ecoregion form the eastern watershed for the Save River which flows south, then east, across Mozambique, flowing into the Indian Ocean.

There is one protected area in this ecoregion in Mozambique, the 3,750 km² Gorongoza National Park. Landmines were planted primarily on the Mozambican side of this ecoregion during Mozambique’s civil war and the Zimbabwean war of independence.

5.16.7 ZAMBEZIAN COASTAL FLOODED SAVANNA

The Zambezi River floodplains make up the most extensive portion of this ecoregion, covering roughly 200 km along the coastline and penetrating up to 120 km inland. The Buzi and Pungwe rivers flood around 4,500 km² of wetlands in their deltas, while a number of small swamps at the mouth of the Save fall into this ecoregion.

Located in the sub-tropical climatic belt of Africa, the ecoregion is characterized by mild temperatures, with most of the rain falling in the warm summer months. A high-pressure system dominates over the southern African plateau for much of the year, and northeast and southeast airstreams from the Indian Ocean bring rain to the area during the months of October to March. The ecoregion experiences annual rainfall of 800-1,400 mm per annum. Mean maximum temperatures range between 27 and 30°C, with mean minimum temperatures averaging 18°C.

The Zambezi delta has amongst the highest diversity of habitats in the Zambezi basin, which is reflected in a high species richness of mammals and birds, including overwintering and breeding waterbirds.

Until the 1970's, much of the ecoregion was subject to seasonal flooding that spread out onto the floodplains at the onset of the rainy season. It was only with the construction of large dams such as the Cahora Bassa and the Kariba on the Zambezi River that these important inundation events were severely reduced.

At present, the Marromeu Complex Game Management Area in the Zambezi delta is the only officially protected area within this ecoregion. In addition to Marromeu, calls have been made to designate the Zambezi delta as a wetland of international significance under the Ramsar convention.

5.16.8 EAST AFRICAN MANGROVES

The East African mangroves are an ecoregion consisting of mangrove swamps along the Indian Ocean coast of East Africa in southern Mozambique, Tanzania, Kenya and southern Somalia. The ecoregion consists of two large areas of mangrove in the deltas of the Zambezi in Mozambique and the Rufiji River in Tanzania, as well as smaller areas along the coast. This coast experience two monsoon seasons each year, strong ocean currents and rising seas up to 5.6 m in Mozambique. Annual rainfall averages range between 750 and 1,500 millimeters (mm). Maximum tidal amplitudes are 5.6 m in Mozambique.

Because of their high productivity and the availability of sheltered areas needed by juvenile fish and other marine organisms, Eastern African mangroves along open coasts enhance biodiversity in neighboring
habitats such as coral reefs, which are nutrient poor, and which, in turn, shelter the mangroves from harsh wave action. The large areas of mangrove found at river mouths, especially in the deltas of larger rivers, provide important habitat for migratory birds. Because of their ecological functions, these mangroves are important to many animals not exclusively associated with mangrove areas, including the dugong, several species of marine turtle and different species of porpoise.

The most developed mangroves are found between the Beira and the Save Rivers in Mozambique, where they extend up to 50 km inland with canopy heights of up to 30 m. The major river drainages with the most extensive mangroves in Mozambique is the Limpopo.

The Bazaruto Archipelago in Mozambique provides an example of mangroves found in conjunction with a variety of other habitats: coral reefs, seagrass beds, rocky intertidal areas, and dune forest. These mangroves, combined with the other habitats, support a large number of threatened and endangered turtles and marine mammals, and are particularly important for the survival of probably the last viable population of dugongs in Eastern Africa. The Zambezi delta in Mozambique supports a huge prawn fishery just offshore and in the vicinity of the mangrove stands there are many large sharks, a humpback whale nursery, notable populations of porpoises and the mangroves themselves provide an important stopover site for migratory wetland birds.

Protected areas containing mangroves include Bazaruto Marine National Park, Ilhas da Inhaca e dos Portugueses Faunal Reserve, Marromeu Game Reserve, Pomene Game Reserve, and Maputo Game Reserve in Mozambique.

5.16.9 ZAMBEZIAN HALOPHYTICS

The Zambezian halophytics ecoregion includes two spatially disjunctive units in Southern Africa: The Makgadikgadi Pan complex in Botswana and a smaller hypersaline unit in Changane Valley in southern Mozambique. Halophytic communities are widespread in the Changane Valley, which runs in a north-south direction generally tracing the 34°E line of longitude, from about 22°S to about 24°S latitude. The saline affinity vegetative communities range from wetlands to seasonally flooded grasslands. The valley is also semi-arid, with an annual rainfall of between 400 and 600 mm, mostly falling between October and April. In the past few years however, rainfall in this area has increased dramatically causing major flooding and widespread devastation. In March 2000, 500 mm fell in merely three days.

5.16.10 MAPUTALAND COASTAL FOREST MOSAIC

The Maputaland coastal forest mosaic is an ecoregion of the subtropical moist broadleaf forests Biome, on the Indian Ocean coast of Southern Africa. It covers an area of 30,200 km² in southern Mozambique, Swaziland, and the KwaZulu-Natal Province of South Africa. Mozambique's capital, Maputo, lies within the ecoregion.

The Maputaland coastal forest mosaic occupies the humid coastal strip along the Indian Ocean, inland to the Lubombo Mountains for much of its length. The northern limit of the ecoregion is north of the mouth of the Limpopo River, near Xai-Xai in Mozambique. The ecoregion has a seasonally moist, tropical to subtropical climate. Rainfall ranges from 1000 mm per year near the coast to less than 600 mm per year inland. Most of the rain falls in the summer months.

The ecoregion comprises a mosaic of many different plant communities, from the forest of the Lubombo Mountains through savanna, woodland, palm veld, grassland, sand dunes with patches of dense forest, and wetland habitats. The flora of the region includes a number of endemic species.

The 100 species of mammal found here include the African elephant (Loxodonta africana), now contained in reserves along the coast, and large predators, of which leopard (Panthera pardus) are the most common. More than 470 bird species are found here, of which 4 are endemic and 43 near endemic. The Maputo Reserve is located in this ecoregion.
6. PESTICIDE PROCEDURES

Regulation 22 CFR 216.3(b) mandates the consideration of twelve factors when a project includes “assistance for the procurement or use, or both, of pesticides”. This section addresses each of those twelve factors for the Malaria Control Program in Mozambique.

6.1 THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY’S REGISTRATION STATUS OF THE REQUESTED PESTICIDE

Pesticides registered for IRS in Mozambique and the United States, and recommended by WHO, will be preferred for use in this IRS project. However, some of the pesticides on the WHOPES list are not registered with the U.S. Environmental Protection Agency (USEPA), for economic reasons rather than health and safety or technical ones. Because this is an economic issue rather than a technical one, and because there is widespread use of these chemicals around the world, with a good database attesting to the safety of the chemicals, USAID and USEPA has chosen to allow the use of all WHO-recommended pesticides under the Africa IRS program. Currently, chlorfenapyr is under review by WHOPES and is currently registered by the USEPA for some agricultural uses, but has not been registered for public health use.

The agricultural pesticide regulating body in Mozambique is the MINAGRI Crop Protection Department. Currently, the four class groups recommended by WHO for IRS activities, organochlorines, pyrethroids, carbamates, and organophosphates, are registered by the MINAGRI for use in public health. Generally, MISAU/MOH pesticide use is not regulated by MINAGRI, and follows their own pesticide handling regulations. All applicable Mozambique laws and regulations regarding the public health use of the WHOPES-recommended pesticides will be followed.

6.2 THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

Insecticide selection for any PMI supported program is subject to international procurement requirements of the US Federal laws. Requests to purchase public health insecticides used in IRS must be initiated at class level, rather than for a particular insecticide (compound). The insecticide class to be used in IRS is selected for each campaign based on a number of considerations. The insecticide selection and the timing of the spray cycle are dictated by MISAU/MOH and are based on the results of annual entomological studies. Generally, the insecticide will be supplied by MISAU/MOH, which is procuring the national need for IRS insecticides with Global Fund support. MISAU/MOH plans to rotate insecticides every two years, and the specific selection of insecticides for a rotation cycle will be determined based on insecticide susceptibility data. Both insecticide choice and rotation cycle may vary based on the results of annual resistance testing.

Primary Criteria for choosing pesticides:

1. Approval by the World Health Organization Pesticide Evaluation Scheme: Currently, only insecticides recommended by WHO can be used in IRS. OPs, carbamates, pyrethroids and organochlorines are WHOPES recommended classes of pesticides for use in IRS and thus any can be chosen for use based on entomological data and host country registration status. Chlorfenapyr belongs to the pyrroles class of chemicals, which are not yet included in the WHOPES-recommended classes for IRS. Registration for use in the country: The pesticides recommended by WHO for IRS are registered for use in public health by MINAGRI. Chlorfenapyr is
currently not registered for public health, and will need to go through the approval process before it can be used in IRS activities, including hut trials.

b. **Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area:** According to WHO, all pyrethroids, carbamates, OPs and DDT are expected to have duration of 3 to 6 months in terms of effectiveness; however, the duration of effectiveness varies under different climatic conditions. In most of the country, the peak periods of malaria incidence occurs during the peak rainy season from December to April. The PMI implementing partner has been using pyrethroids. Results from the entomological studies indicate that both deltamethrin and alphacypermethrin were effective for three to four months post-spraying. Technical information on duration of effectiveness on the primary wall surface types will continue to be considered when selecting insecticide class(es).

c. **Pesticide must be appropriate for use on the wall surfaces of the selected location:** The majority of the structures in the targeted regions are made of clay brick, thatch/wood covered with a mud plaster, and in the southern regions the homes may be constructed of bamboo stalks or corrugated zinc sheets. Many of the homes have plastered and painted walls. Structures made of corrugated metal are not sprayed, as the pesticides do not adhere sufficiently to the surface to be effective. In Mozambique, only the inside of the walls are sprayed, ceilings and eves are not sprayed. Human Landing Catches showed that *Anopheles gambiae* s.l. and *Anopheles funestus* tend to feed mainly indoors in regions where there is no IRS. In regions where IRS is being implanted, biting rate was generally low, or an increase in outdoor feeding (exophagic) was observed.

d. **Local vector susceptibility to the insecticide:** One of the major concerns when implementing an IRS campaign is to prevent resistance to insecticide among vectors. Resistance to insecticide develops when a hereditary feature is selected in an insect population that reduces the population’s sensitiveness to a given insecticide. PMI has provided a significant amount of support to build Mozambique’s entomological capacity both at the central level and regionally. The PMI-supported central entomology laboratory and insectary at the INS in Maputo is operational and serves as the reference laboratory for in-country processing of mosquito material. The PMI-supported entomology laboratory and insectary in Quelimane, Zambézia Province, serves as a regional center for entomologic monitoring and surveillance for IRS and LLIN activities in the central provinces of Mozambique.

PMI is supporting the development of a vector control strategy and an insecticide resistance monitoring plan to guide vector control efforts in a coordinated, evidence-based manner. Insecticide resistance to pyrethroids has been well documented in southern Mozambique and in other sub-Saharan African countries; it can have a devastating impact on the effectiveness of both IRS and LLINs. WHO resistance tests were conducted with bendiocarb, deltamethrin, DDT, and lambdacyhalothrin. Insecticide resistance varied between provinces. Lambdacyhalothrin resistance was noted in *An. gambiae* s.l. in Cabo Delgado (79% mortality) and in Tete (87.2% mortality). For *An. funestus* s.l., bendiocarb resistance was found in Maputo (89%), and lambdacyhalothrin resistance was observed in Inhambane (88%). The INS and NMCP are collaborating in the molecular speciation of the mosquitoes collected for insecticide resistance testing. Insecticide decisions will be based on annual resistance data, ideally rotating between non-pyrethroid insecticides at least every two years. Chlorfenapyr has a unique mode of action that should limit the rate of resistance development to it. It is also not cross-resistant to DDT, pyrethroids, carbamates, or organophosphates.
e. **Ecological impact:** The 2012 PEA for Integrated Vector Management (IVM) assessed the toxicity of IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and 'other aquatic' organisms. In summary, pyrethroids and carbamates are similar in toxicity to non-target organisms as shown in Table 7. Apart from propoxur, the rest of the insecticides are all highly toxic to fish and other aquatic organisms. Similarly all the insecticides from the approved classes are highly toxic to bees, apart from pirimiphos methyl. In mammals, all the insecticides approved by WHO for IRS carry low-to medium toxicity, with the exception of lambda cyhalothrin and propoxur, which are categorized as highly toxic to mammals. There has been much concern over chronic exposure of bird species to DDT and its effects on reproduction, especially eggshell thinning and embryo deaths. In avi-fauna, only propoxur is categorized as highly toxic with the rest categorized as low/medium in toxicity.

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<th>IRS Insecticide</th>
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<th>Fish</th>
<th>Other Aquatic</th>
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<th>Persistence</th>
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Source: IVM PEA

**Key**

- High Toxicity
- Medium to High Toxicity
- Medium Toxicity
- Low to Medium Toxicity
- Low Toxicity
- Data Not Found

f. **Human health impact:** The 2012 PEA for IVM also assessed cancer and non-cancer risks associated with all WHOPES-approved insecticides by process (e.g., mixing insecticide, spraying,

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PMI Programmatic Environmental Assessment, INTEGRATED VECTOR MANAGEMENT PROGRAMS FOR MALARIA VECTOR CONTROL (2012 UPDATE)
residing in sprayed house, etc.) and pathway (e.g. inhalation, dermal, ingestion, etc.), and cancer risks by process and pathway where available (mainly for DDT and select pyrethroids). In general, pyrethroids and carbamates pose less non-cancer risks than OPs when risks are assessed via any pathway. If OPs are used, then decisions on insecticide type should be informed in part by the human health toxicity and risk associated with each compound and formulation. For malathion and fenitrothion, it will be necessary to monitor the level of acetyl cholinesterase in any worker who may have been exposed to contamination. Occupational exposures to OP insecticides are measurable using blood cholinesterases and urinary excretion of chemical biomarkers. PMI will evaluate various approaches for monitoring sprayer exposure to OPs, and will develop protocols based on these evaluations. PMI will use these protocols to guide the implementation of any OP monitoring program. An investigation will need to be conducted to determine if Mozambique has the capability to conduct biomonitoring and what level of capacity building would be required. All of the IRS facilities are located at district health centers; therefore, biomonitoring could be completed at these centers.

Secondary Selection Criteria:

Once the NMCP/Global Fund and PMI approve the analysis of these factors, then the criteria is updated to include international procurement language in which the criteria is clearly stipulated and then tendered out in accordance with international open competitive procurement rules. Once there are responses to the call for bids, the resulting proposals are subjected to secondary criteria including:

- Appropriate packaging for safety and standard delivery tools
- Unit cost of insecticide
- Timely delivery of the insecticide to the preferred point of delivery
- Local representation of supplier in host country
- Technical assistance with training and troubleshooting by supplier
- Supplier is accountable for disposal of DDT waste

6.3 The Extent to Which the Proposed Pesticide Use Is Part of an Integrated Pest Management Program

Integrated Pest Management (IPM) is defined\(^\text{21}\) as:

‘‘…an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties [agricultural products]. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials [pesticides] are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.’’

Mozambique is in the process of updating its Integrated Malaria Vector Control Strategy (IMVCS). IMVCS was developed to reorient and better coordinate vector control interventions.

\(^{21}\) [http://www.ipm.ucdavis.edu/IPMPROJECT/about.html](http://www.ipm.ucdavis.edu/IPMPROJECT/about.html)
IPM is often used in an agricultural context, but similar in nature is the concept of IVM. The major characteristics of IVM include:

- Methods based on knowledge of factors influencing local vector biology, disease transmission, and morbidity;
- Use of a range of interventions, often in combination and synergistically;
- Collaboration within the health sector and with other public and private sectors that impact vectors;
- A public health regulatory and legislative framework.

USAID strategy has been that IRS will be implemented as a component of IVM for malaria control, along with LLINs. Larviciding and environmental management are not generally recommended for large-scale malaria vector control. These other interventions are described in a preceding section on Proposed Action and Alternatives.

6.4 PROPOSED METHODS OF APPLICATION

IRS involves spraying a liquid insecticide with long lasting residual activity on the indoor wall surfaces where mosquitoes usually rest. The pesticide then dries up and leaves a crystalline deposit on the sprayed surface. A lethal dose of the insecticide is absorbed when the mosquito rests on the surface, and the mosquito is killed.

Pesticide will only be applied using pressurized spray equipment approved for the pesticide in use, by trained spray operators wearing full PPE (face mask, gloves, overalls, hard hats with face shields, boots, neck protection and goggles). Experienced program operators will train spray operators in the correct spray procedures per PMI IRS BMPs. These procedures have been proven to be effective for providing long-lasting effectiveness toward controlling the malaria vector mosquito.

The following IRS equipment will be used:

- **Spray Nozzles**

  The program in Mozambique will procure 8002E nozzles for the spray pumps, which are the standard size recommended by WHO for mud and brick walls.

- **Spray pumps**

  The spray operators who implement IRS use HUDSON X-PERT or Goizper backpack compression sprayers to apply a measured amount of insecticide on the interior walls of houses and structures. A water-soluble insecticide is added to the sprayer containing a pre-measured amount of water, the sprayer is pressurized, and the material is then applied to the interior walls of targeted house (structure). After the day’s spraying is complete, spray operators must clean the sprayer following the manufacturer’s recommendations to ensure their proper operation and calibration.

6.5 ACUTE AND LONG-TERM TOXICOLOGICAL HAZARDS AND MEASURES TO MINIMIZE THEM

The two broad categories of hazard are exposure to humans and domestic animals, and release into the environment causing environmental damage. These may occur at any point, from the production or importation of the pesticide through transportation, storage, distribution, pesticide preparation, spray application, cleanup, and final disposal. Post-spray activity may cause exposure as well through improper behavior of beneficiaries regarding sprayed surfaces and cleanup and disposal of residue and any insects killed with the insecticides from the household after spraying. Hazards are discussed in the Environmental Impact section and addressed in the EMMP in Annex A. The EMMP includes mitigation.
strategies for each of the risks. The consequences of release and exposure are found in Table 7. The acute and long-term toxicological hazards of DDT, pyrethroids, carbamate and OP-based pesticides are detailed in Annex E: Pesticide Profiles of the PMI IVM PEA.

Major hazards include exposure during handling (transporting or spraying), environmental release through vehicular accidents during transportation, and widespread airborne release of pesticide combustion byproducts in the event of a fire at the storage facility or in transport. Although the PMI IRS BMP manual is the operative document, the Pesticide Storage and Stock Control by FAO provides detailed guidance on proper storage management practices, as well as remedial measures in case of spillage and incidents brought on by natural disasters including flooding. These guidelines therefore provide a sound basis for minimizing the risk of human, animal, or environmental exposure. It is not incumbent on the PMI Mozambique implementing partner to observe all recommendations from the FAO manual.

Exposure treatment for DDT, carbamates, pyrethroids, chlorfenapyr and OP-based pesticides are detailed in Annexes C and D. Training for supervisors, spray team leaders, spray operators, washpersons, storeroom managers, and health officials include recognition of the symptoms of poisoning, incident response elevation protocol, and, for the medical professionals, the treatment protocols for each pesticide.

Specific measures to mitigate transportation-related exposure will include:

- Training drivers before they transport insecticides from the customs warehouse or central storage facility to the local storage facility.
- Ensuring that drivers are thoroughly knowledgeable about the toxicity of insecticides, and that training includes opportunities for drivers to respond to scenarios related to the transport of specified insecticides, and
- Knowing the routes that must be negotiated to transport the pesticide to its destination, and the hazards that exist along those routes. The drivers will also be trained on mitigation of those hazards.

Drivers must remove any pesticide contamination in vehicles rented for the project in order to avoid negative consequences when the vehicles are used for other purposes, such as food transport. To prevent pesticide runoff from vehicle washing, drivers are responsible for wiping the vehicle bed with a damp cloth before washing the exterior of the vehicle.

Other than transporters, storage area personnel, and spray teams, the people at risk of exposure are primarily the beneficiary population in the targeted communities. Acceptance of the pesticide and IRS intervention among the targeted households are primary external factors critical for compliance. The IEC program is of critical importance toward gaining beneficiary acceptance. It is important that the targeted community and households are adequately educated on safety, including procedures for removing personal belongings prior to spraying, observing the required exclusion period, and avoiding contact with sprayed surfaces on an indefinite basis.

IEC programs, also referred as Behavior Change Communication (BCC) programs, are currently being implemented in targeted communities under the ongoing IRS operation.

The main purpose of mobilization is to remind beneficiaries about the positive benefits of IRS in controlling and preventing malaria and malaria-related deaths, and to remind them of their roles and responsibilities before, during, and after spray operations in the elimination or mitigation of any possible negative impacts.

The PMI IRS implementing partner collaborates with the NMCP at all levels to mobilize communities. IEC mobilizers are selected from the communities. DPS, SDSMA and IEC supervisor along with the IEC mobilizers take part in the mobilization campaigns in both rounds of spraying. Door-to-door communication is the main strategy used for community outreach. Also, Base supervisors work in close
contact with the team leaders to inform the population about the spraying schedule. The project develops, prints, and distributes household IRS cards as well as IRS fliers, brochures and posters with key IRS messages.

6.6 **THE EFFECTIVENESS OF THE REQUESTED PESTICIDE FOR THE PROPOSED USE**

Pesticides are selected by MISAU/MOH/NMCP for IRS based on efficacy in the intended use, and other extrinsic variables. Selection criteria have been expounded in the Description of Alternative and Proposed Actions section, and in Section 6.2 of this Pesticide Procedures section.

Once the program is established, it is necessary to monitor vector resistance prior to the initiation of spray activities, to ensure that acceptable kill levels will be achieved. A resistance monitoring program has been established and is operating, and the results from this ongoing program will be a primary determinant of the choice of pesticide and other supplementary actions.

Pesticide efficacy is also affected by vector behavior, insecticide quality, and the residual action of the pesticide. The probability of vector-pesticide contact depends on whether the targeted vector feeds indoors (endophagic) and rests indoors (endophilic), as this increases the likelihood of the vector resting on the sprayed wall. The efficacy of the pesticide to kill may be either compromised if the vector exits after feeding without resting on the wall, or absent if the vector feeds outdoors (exophagic) and rests outdoors (exophilic). Overall human landing catch collection results showed that vector biting was consistently higher indoors than outdoors, indicating a tendency of endophagic habits. This is characteristic of *Anopheles gambiae* s.l. and *Anopheles funestus* s.l., which are the dominant vectors in Mozambique.

Knowledge of vector susceptibility is critical to planning and evaluating the effectiveness of the IRS program. It enables timely forward planning to (i) manage the development of the resistance and (ii) evaluate new or alternative insecticides for possible future introduction should a change of pesticide be required. Resistance testing is done to (i) establish a baseline susceptibility of the local vectors for future reference, (ii) monitor changes that occur as time progresses, (iii) identify the mechanisms of resistance and cross-resistance to inform the resistance management strategy that will be adopted, and (iv) evaluate the susceptibility of the local vectors to potential alternative insecticides, should there be a need to change pesticide. The operational criterion for vector resistance is having 10% or more survival rate in the number of mosquitos tested using standardized methods of the WHO.22

Vector resistance may differ in origin, intensity, type, and significance for vector/disease control in a given population. The evaluation of the significance of resistance to vector control should therefore consider the biochemical and genetic characteristics of the resistance, as well as the eco-epidemiology of the disease and operational characteristics.23, 24 Resistance also tends to be highly focal (i.e., limited to a definite area). It is therefore important to ascertain the spatial distribution of the observed resistance to better inform the resistance management strategy to be employed and the geographical extent to which it will apply (e.g., what geographical area a possible change in pesticides for IRS will cover). Generally, a positive correlation between observed vector resistance and a decline in pesticide efficacy is an important criterion in determining the need for a change of the pesticide in a local area.

Irrespective of the pesticides used for IRS, national capacity is being strengthened to enable systematic evaluation of the mechanisms for resistance development and the gene frequencies among the local malaria vector populations. There is also a need to evaluate other pesticides and non-chemical alternatives to facilitate the evolution of a full-fledged IVM for malaria.

The residual efficacy of the pesticide being used for IRS is crucial to evaluating the implication of vector resistance. It is important that wall bioassays be carried out at specified intervals after the IRS operation in order to determine the period and level of residual activity in a given locality and the sprayed surface.

The third major factor affecting the effectiveness of the pesticides is their quality (strength and other factors). If the active ingredient, for example, is not up to the recommended specification and concentration, it may lead to under-dosage of deposited pesticide, which then contributes to intervention failure. Storage of pesticide for too long a time, or in extremely hot warehouses can lead to breakdown of the active ingredient. Poor pesticide quality may present additional risks to the pesticide handlers and spray operators who may be exposed. For this reason, samples of the pesticide should be taken prior to use, and analyzed for the concentration of the active ingredient.

6.7 COMPATIBILITY OF THE PROPOSED PESTICIDE WITH TARGET AND NON-TARGET ECOSYSTEMS

The WHOPES-recommended pesticides are compatible with the target environment (indoor walls) in that they dry on these surfaces, and are not released to any great extent. The dried pesticide remains on the sprayed surfaces, and performs as designed, killing vector mosquitos that rest on those surfaces. In fact, there is a high potential for a positive impact on the target environment because of corollary reduction of other household pests.

The proposed pesticides are incompatible with the non-target ecosystems (humans, animals, and the environment), in that if they are released to the non-target environment in large quantities, they would have negative effects on humans, as well as land and water based flora and fauna.

The IRS implementation process is carefully designed to ensure that pesticides are deliberately and carefully applied via strict protocols to the interior surfaces of dwellings, and do not come in significant contact with humans, animals, or the environment. IRS implementation protocols minimize and responsibly manage IRS liquid wastes, through the next-day reuse of mixed but unused pesticides drained from operators’ spray tanks at the end of the day, and the triple rinsing process. At the end of the spray season, contaminated solid wastes are incinerated in approved incinerators that destroy the pesticide and prevent environmental contamination. The EMMP in Annex A details the steps and measures that will be taken to prevent negative impacts on the non-target ecosystems.

6.8 THE CONDITIONS UNDER WHICH THE PESTICIDE IS TO BE USED

Chapter 5, Affected Environment of this SEA discusses in detail the environmental background conditions that exist in Mozambique relative to the implementation of IRS. Malaria is endemic throughout Mozambique, and most of the country has year-round malaria transmission with a seasonal peak during the rainy season, from December to April.

During IRS, particular attention will be paid to any sensitive areas identified in Chapter 5, including water bodies, schools, hospitals, any area where organic farming is practiced, where bee-keeping or natural bee habitats are established, etc. In addition, bird-nesting habitat will be protected, and all insecticides will be kept away from all water habitats and resources. Prior to spraying, geographical reconnaissance will include identification of households in sensitive areas, and sprayers will be trained to identify houses that should not be sprayed. IRS will be prohibited within 30 meters of sensitive ecosystems. If pesticide drift is observed, spraying will be halted until the cause has been determined. Drift could be a result of...
spraying an inappropriate surface with gaps that allow pesticide to escape, so the wall surface must be evaluated for fitness for spraying, and the structure potentially disqualified. Alternately, if drift is caused by excessive wind (especially if spraying eaves outdoors) operators must wait until wind conditions subside. The IP will consult with DPMA regarding the application of pesticides in or near ecologically sensitive areas, such as wetlands, lake shore, river edge and protected areas and follow their policies and guidelines, unless the conditions prescribed herein are more strict, in which case the SEA will have precedence. Strict supervisory control will also be established to prevent contamination of agricultural products.

6.9  **THE AVAILABILITY AND EFFECTIVENESS OF OTHER PESTICIDES OR NON-CHEMICAL CONTROL METHODS**

This IRS program is limited to using those pesticides that WHO currently recommends, comprising 14 insecticides (WHO 2013) from four chemical groups, each with a specific dosage regime, duration of effectiveness, and safety rating. A relatively new pesticide, chlorfenapyr, which is a pyrrole class, will also be considered for the IRS program, once recommended by WHOPES. Each of these agents has been evaluated for effectiveness within the program, and continued monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign. PMI programs in other countries (Nigeria) are assessing the efficacy of chlorfenapyr. PMI Mozambique may also decide to conduct similar studies. The goal of this SEA is to broaden the options for pesticide use to combat periodic resistance development.

Non-chemical control methods include behavior modification and use of untreated bednets. While the IEC program includes certain types of behavior modification to avoid or reduce the probability of beneficiaries contracting malaria, untreated nets are not used, in favor of treated nets. Luring and trapping of vector mosquitos remains a possibility, but in general, luring is accomplished by the use of some type of chemical, which may or may not have toxicity characteristics. The PMI IRS implementing partner will remain alert to the possibilities for other non-chemical control methods, and will continuously evaluate the utility and practicality of these methods.

6.10  **THE REQUESTING COUNTRY’S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE**

The MINAGRI Agriculture Department is responsible for regulating the registration, importation and use of agricultural pesticides. MINAGRI has a list of registered public health pesticides, but in general, MISAU/MOH IRS use of public health pesticides is not regulated by MINAGRI. In keeping with following all country regulations, PMI program will follow MINAGRI Pesticides Regulations in the IRS program. Mozambique’s Ministry for Coordination of Environmental Action is the principal authority for the management of environmental issues. MICOA sets national environmental policy and enforces environmental regulations at the federal level. Department Provincial of Environment (DPMA) offices oversee activities at the provincial level. In general, MICOA is not involved with overseeing the environmental aspects of NMCP activities, though they do partner with the PMI implementing partner in

Zambezia. The DPMA has been closely involved and accompanies the PMI Mozambique ECO when performing assessments of facilities prior to the spray season. They make recommendations for improving these facilities, and these recommendations are acted upon during the preparation for spray. A DPMA representative also accompanies the ECO for inspections of spray operations, including morning mobilization and end-of-day cleanup activities, to be sure that the mitigation methods called out in this SEA are followed. Finally, the DPMA performs final close-out inspections at the end of the spray season to ensure that proper measures are followed to secure the facilities during the off season.

The quality of the pesticide used can have a large impact on the effectiveness of the IRS undertaking. Pesticides that are procured by the Global Fund for NMCP are tested for efficacy and chemical composition. Pesticides that are procured from a reputable manufacturer and have documented test results will not need to be retested, unless they are exposed to potentially degrading circumstances, or are not used prior to the expiration date.

6.11 THE PROVISIONS MADE FOR TRAINING OF USERS AND APPLICATORS

The effectiveness of the IRS program depends on the availability of adequately trained spraying personnel, well-maintained equipment, and competent supervision, as well as end-user acceptability and compliance. USAID has developed guidelines for IRS operations ("PMI IRS Best Management Practices", "Spray Operator Pocket Guide", "AIRS IRS Storekeeper Pocket Guide", "IRS Team Leader Guide"), and WHO provides a training manual Manual for Indoor Residual Spraying. Although PMI-produced documentation has precedence over other guidance, information from other sources may be useful and may be followed if the recommendations do not conflict with PMI sources. Other resources include the WHO-UNEP Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning, the 2012 PEA and this SEA, all of which provide precise precautions and recommendations on many aspects of IRS operations.

A complete description of the PMI Mozambique training program is found in Chapter 8, the Safer Use Action Plan.

6.12 THE PROVISIONS MADE FOR MONITORING THE USE AND EFFECTIVENESS OF THE PESTICIDE

Two kinds of measurements are needed to provide a complete understanding of the effectiveness of pesticide that is being used for IRS. The immediate (output) level relates to the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors, and involves direct entomological evaluations on pesticide contact bioassays and related pesticide resistance methodologies as recommended by WHO. The second broad level of measuring the effectiveness of the pesticides relates to the general goal of reducing the local disease burden. This will require specialized entomological and epidemiological skills and the assessment of the impact of vector control operations, and possibly the assignment of the contributory impact of the IRS operations. This latter measurement is usually done through a combination of methodologies such as measuring the changes in parasite inoculation rates, passive case detection at health centers, and periodic community fever and parasite surveys (active case detection).

Another key characteristic of pesticide effectiveness is the longevity of the treatment. This characteristic has important economic and health implications: the program must adjust its spray schedule to make sure that there is active pesticide on the walls of homes during critical breeding periods. Unfortunately, the guidance that is provided with regard to effective period for each pesticide is very broad (e.g. 3-6 months), and the effective period is probably subject to complex environmental factors such as heat, humidity, and substrate (wall) composition.

The PMI IRS implementing partner work closely with the NMCP and the DPS to conduct entomological monitoring. The first entomological data collection on vector density, distribution, and seasonality and behavior is done three months before the start of spray operations. Subsequent monthly post-spray entomological monitoring activities are continued on a monthly basis up to end of the project period. Pyrethrum spray collection is done before and during spraying to determine densities and mosquito species at selected sites. Human landing collections are carried out at selected sites and collections are done inside and outside the structures to determine the exophagy or endophagy habits of the mosquitoes. The standard WHO cone bioassays are used to evaluate the quality of the spray operation. The bioassay tests are conducted 24 hours after spraying and monthly after spraying in selected sites.
7. Potential Health and Environmental Consequences

This section addresses the potential direct and indirect impacts of the IRS program in Mozambique, and briefly discusses mitigation and monitoring measures. The EMMP, in Annex A, presents the best management practices and mitigation measures identified for the project, responsibilities for the implementation of the Plan, and monitoring and reporting measures. This EMMP is the guiding document for IRS management team in Mozambique, and will be used as the tool for ensuring environment compliance for the program. The EMMP Annual Reporting Form and Certification will be completed and submitted to the COR as part of the annual end-of-spray report (EOSR).

7.1 Potential Positive Effects of the IRS Program

7.1.1 Direct Positive Effects

The direct positive impacts of the IRS program are the reduction in child and adult malaria morbidity and mortality that will result in a reduction in human suffering. In addition, economic losses due to absenteeism or inability to work will be reduced. Other positive impacts include reduced incidence of miscarriages, low birth-weight, adverse effects on malaria-induced fetal neurodevelopment, and reduced incidence of malaria-related childhood and maternal anemia, complications, and organ failure. There is also the benefit of elimination of other household insects, as well as vermin in some cases.

7.1.2 Indirect Positive Effects

IRS will build human and institutional capacity by providing broad-based training to a large number of people associated with IRS operations. From this training, there will be an increase in knowledge and understanding of both IRS-specific and general health and environmental risks and impacts, as well as methods of mitigation of those risks. One of the goals of the IRS program is to build in-country capacity to the point where IRS can be conducted by national or local government, or by the self-organization of communities, without large-scale external assistance or intervention.

By reducing the malaria burden, the IRS program will improve the education level amongst children of school going age, as a result of the reduction in the number of school days missed, and improve the productivity of the workforce as a result of the reduction in missed work days and days of reduced productivity.

The IRS program will indirectly contribute to the enhancement of the local economy in that IRS staff and workers will receive payment for their work. At least some of the money that they receive will be spent and injected into the local economy with a magnification effect, improving revenues for various businesses and per capita income. In addition, the implementation of IRS requires certain local purchases of products and services, such as building and construction materials, rental of building space and vehicles, and hiring of local labor for the construction or renovation of storehouses and soak pits. Again, these revenues are injected into the economy with potentially positive magnification effects.

Finally, a reduction in household pests from IRS may result in a reduction in other diseases carried by the pests.
7.2 POTENTIAL ADVERSE IMPACTS

Adverse impacts of the IRS project are those unintended effects of the project that can compromise the well-being of the environment and/or human health. Table 2 in section 6.2 provides a graphic representation of the potential impacts on various receptors, as well as certain physical and chemical properties of the WHOPES pesticides.

7.2.1 DIRECT POTENTIAL ADVERSE EFFECTS

7.2.1.1 CONTAMINATION OF SURFACE WATERCOURSES AND UNDERGROUND WATER

During IRS implementation, it is possible to accidently release insecticides into water bodies during the transportation and storage of pesticides, application of insecticides to walls, and clean-up of IRS equipment and PPE. It is also possible to have a release that will affect surface or groundwater through washing in areas other than the soak pit, or improper disposal of leftover pesticide. A spill into surface water bodies is a key concern in IRS because it could lead to contamination of water routinely used for multiple domestic purposes. Fish and other aquatic organisms that are vital to a healthy ecosystem could also be wiped out.

Contamination of underground water resources is possible through improper disposal of leftover pesticide on the ground, especially if there is a high water table. However, the impacts of this risk are likely to be insignificant, primarily because pesticide disposal is strictly controlled and supervised, and the sites for soak pits are carefully chosen according to the criteria in the PMI BMPs. Secondarily, most formulations of pyrethroids, OPs, and carbamates move slowly through soil, and degrade quickly when exposed to sunlight, hydrolysis, or microbial action in the soil. If wash areas and soak pits are properly constructed and employed, liquid pesticide traces will be captured in the charcoal layer of the soak pit or organic matter in soil, and held until degradation by natural processes.

7.2.1.2 POTENTIAL IMPACTS TO NON-TARGET ORGANISMS FROM PESTICIDES

The degree of toxicity of the four WHOPES-recommended pesticide classes and chlorfenapyr to birdlife, aquatic life and insects, as well as pesticide persistence and bio-accumulation potential is documented in Table 2 in Section 6.2 of this SEA.

7.2.1.3 SPECIAL NOTE: IMPACTS ON BEES

Spraying in areas near beehives can lead to the death of the bees, which are vulnerable to all WHO-recommended pesticides. In addition, spraying near hives can lead to contamination of edible honey. These risks must be mitigated at all times. The project will identify locations where beehives are kept, and observe a 30 meter no-spray buffer zone around them. Beehive owners will be advised accordingly.

7.2.2 INDIRECT ADVERSE EFFECTS

After completion of the IRS program, USAID will properly dispose of the IRS equipment or turn them over to the District Health Offices or to communities; and will no longer supervise its use. IRS equipment left to district health officials includes backpack compression sprayers, used overalls, clean boots, wash basins, progressive rinse barrels, etc. that are still in operable condition. Improper use of this equipment could lead to contamination of the environment or adverse health effects as noted.

In general, if PMI supports the procurement of insecticide or disposition of unused insecticide to the GRM, this activity is required to be mentioned in the annual Letter Report, in addition to this SEA. This type of support requires annual environmental compliance monitoring by USAID and/or the USAID IP, requires that USAID and/or the USAID IP provide environmental training to the GRM in the PMI IRS BMPs, and language must be inserted into the government to government agreement that PMI must
provide technical assistance for insecticide selection to ensure quality/appropriateness of the product. If PMI supports the procurement, loan, or disposition of spray pumps or personal protective equipment to the GRM these activities must be mentioned in the annual Letter Report, in addition to this SEA. These activities do not require environmental compliance monitoring; however, USAID and/or the USAID IP must provide environmental training in the PMI IRS BMPs. These requirements relate to the use of non-DDT insecticides by the GRM. The conduct of IRS by District Health Officers with communities, using properly working equipment left behind by USAID may temporarily, and in a minor way increase the total pesticide load on the environment. However, since the IRS equipment will be in operable conditions and capacity will have been built among the District Health Officers, it is expected that spray operations will be according to BMPs.

7.3 **HUMAN EXPOSURE RISKS/IMPACTS**

Exposure risks of all WHO approved pesticides in relation to cancer and non-cancer endpoints, and with respect to exposure dosage, Hazard Quotient and the Life Time Average Daily Dose are presented in PEA 2012. The exposure risk for cancer and non-cancer endpoints is presented at different stages of the pesticide application including mixing, spraying, post spraying, dermal risk, etc.

**Inhalation exposure and risk during mixing**

- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

**Dermal exposure and risk during mixing**

- From the WHOPES approved list of insecticides to be used in IRS only three (DDT, etofenprox (pyrethroid) and propoxur (carbamate)) have been determined to be carcinogenic at dermal exposure levels of 8E-07 mg/kg-day for etofenprox and 4E-06 mg/kg-day for propoxur.

**Inhalation exposure and risk during spraying**

- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

**Dermal exposure and risk during spraying**

- Of the proposed pesticides, fenitrothion and pirimiphos-methyl have non-cancer risks due to dermal exposure.

**Fetal Exposure (Pregnancy Testing)**

- All female candidates for sprayers operators or washers will be tested for pregnancy before being recruited and every thirty days thereafter until operations end. Females found to be pregnant will be re-assigned to positions that do not have the potential for exposure to insecticides. Women who are breastfeeding cannot have any contact with pesticides, and are thus prohibited from spraying of pesticide, touching or moving pesticide stock, or washing contaminated items.

**Resident dermal exposure and ingestion risk after spraying**

- The only concerns are to adults when using cyfluthrin and etofenprox (pyrethroids) and propoxur (carbamate). The risk is however very low.

- A risk calculation evaluating incidental soil ingestion, soil dermal absorption, inhalation, and vegetable and chicken ingestion pathways indicates that potential DDT exposures by chicken ingestion are by far the most significant and may result in a lifetime cancer risk. DDT exposures of infants via breast milk may also be significant.
Resident exposure and risk due to chronic ingestion after spraying

- There are four insecticides with potential impact due to chronic ingestion by drinking insecticide contaminated water. These are Cyfluthrin, Permethrin and Etofenprox (pyrethroids) and propoxur (carbamate).

Resident dermal exposure and risk due to bathing using contaminated groundwater

- Cyfluthrin and etofenprox (pyrethroids) have potential impact for dermal exposure using contaminated groundwater. When best management practices are applied in IRS, this risk is significantly reduced.

Resident exposure and risk due to reuse of pesticide containers

- Only deltamethrin is registered to have potential for acute ingestion from using pesticide containers. However, residents will have no access to pesticide containers used in IRS. The pesticide containers are only available in IRS storage facilities which are securely double locked and must be disposed by incineration at high temperature.

Worker exposure and risk due to inhalation during spillage

- According to information presented in the PEA, etofenprox and propoxur have potential to impact workers through inhalation during spillage. The workers are trained on how to handle spillage and must be equipped with appropriate PPE.

Worker and Resident Exposure Pathway

During the IRS spraying process, spray personnel are at risk of un-intentional or deliberate exposure through accidents or poor and improper handling of the spray chemical. Worker exposure to the chemical could arise during the pre-spraying, spraying and post-spraying phase of the IRS operations. Beneficiaries can also be exposed during each of these phases, and additionally over the life of the pesticide on the wall.

a. Pre Spraying Exposure Pathway

Preparing pesticide solutions during the IRS requires pouring the pesticide in the spray pump to ensure ample mix with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, mostly from releases of pesticide vapours, and solutions. Vapour releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapours or the particulates or be exposed through dermal contact. Spills could also pose significant risk, especially for children who ingest the resulting residues that are left on surfaces such as food, floors, soil, as well as absorbing additional doses from eating plants and animals contaminated during the preparation for spraying.

b. Exposure during Spraying

Inhalation of aerosol vapours during spraying is the main process for worker exposure during IRS, however, dermal exposure through spills or absorption onto cotton overalls is also a significant risk. Especially in the case of OPs, the dermal hazard is significant, and can cause cholinesterase depression. Residents are mainly exposed through dermal contact with sprayed surfaces and incidental ingestion of insecticide after their houses have been sprayed, especially when food or drink are left in the house during spraying. Leaky equipment can also lead to insecticide exposure through dermal contact with the floors and incidental ingestion by children who may come in contact with the spills before they are cleaned up.

c. Exposure during Disposal (Including Progressive Rinsing)
Disposal is a key issue with IRS intervention that utilizes pesticides especially during the decontamination process and disposal of the liquid effluent that will arise from washing and progressive rinse. Both burying and dumping can lead to dermal exposure to residents who come in contact with the soil or water in which the pesticide was disposed. Ingestion exposure can occur from drinking contaminated surface water. Once the excess formulation gets into the soil, the pesticide can reach the groundwater, which may be used as a water supply via household wells. Residents may then be exposed to this contaminated water by ingestion or by dermal contact when it is used for cleaning or drinking purposes.

d. Occupant long-term exposure from residue

Residents of sprayed structures, especially crawling babies and children, will have a finite exposure risk due to physical contact with sprayed surfaces, as well as small amounts released from substrate walls, ceilings, and eaves, due to physical surface breakdown.

### 7.4 Cumulative Impact

The combined, incremental effects of human activity, referred to as cumulative impacts, pose a serious threat to the environment. Cumulative impacts develop over time, from one or more sources, and can result in the degradation of important resources.

The critical resources or ecosystems that can be affected by the IRS program over a period of time especially with regards to pesticide application include water supply, food supply, waste assimilation/disposal capacity, river, lake, and stream quality, agriculture, aquaculture, apiculture, human and animal health, biodiversity resources, environmental services, and others. Pesticide run-off and accumulation in the rivers, streams and other water bodies, can lead to the progressive contamination of the water resources and reduction of aquatic biodiversity. However, implementing the EMMPs provided in this SEA reduces the likelihood of releases, and the chances of a series of releases within the pesticides half-life are extremely unlikely, except in the case of willful malfeasance.

Continuous human exposure to pesticides over time can lead to health risks or complications, especially among spray operators and others in close contact with pesticides. This is particularly true in the case of OPs. However, the risk assessment performed in the PEA indicates minimal exposure with the use of proper technique and appropriate PPE, i.e. dust masks, helmet, face shield, gloves, overalls and boots that minimize exposure by dermal absorption or inhalation, and a great reduction in the potential for harm.

The sprayed pesticides solidify on the walls, ceilings, and eaves of the structures, and become largely immobile and significantly less harmful. Exposure to the occupants will be further reduced by the procedures and safety measures described in the EMMP.

Organophosphates and DDT are the pesticides with the highest potential for cumulative impacts. Pyrethroids, carbamates, and most organophosphate formulations break down readily in the environment, limiting the risk of cumulative environmental impact.

Repeated exposures to organophosphates result in cumulative cholinesterase depression, with increasingly severe effects. For this reason it is exceptionally important that PPE is worn properly and at all times when pesticide contact is possible. Formulations of the organophosphate pirimiphos-methyl have been used for several years and in several countries without any report of observed symptoms of cholinesterase depression. At the present time, PMI is conducting evaluations to determine the need for closer scrutiny or monitoring.

Because DDT is persistent and has the potential for bio-accumulation, there is a risk of a cumulative impact from long-term use. To mitigate this risk, PMI uses evaporation tanks or other treatment devices to capture and properly dispose of DDT wastes. PMI will also monitor this risk by performing baseline
and ongoing sampling and testing of DDT residues in soil and plants near the IRS operations sites, where the risk of release and build-up is greatest. If analysis should indicate that ambient DDT levels are increasing, the IP will identify and eliminate any PMI-related source of releases.

The long-term use of any pesticide could lead to insecticide resistance. To minimize this cumulative impact, insecticide resistance is actively monitored. The proposed action is designed with the concept of vector monitoring, insecticide rotation and mosaicking which will reduce the future incidence of vector resistance.
8. SAFER USE ACTION PLAN

8.1 IMPLEMENTATION CONDITIONS

During implementation, USAID/PMI/Mozambique and its PMI IRS implementing partners will adhere to the conditions detailed in this SEA, which are summarized below, and in more detail in the Environmental Monitoring and Mitigation Plan (EMMP), Annex A of this report.

8.1.1 PREPARATIONS FOR SPRAY

Prior to spraying, the contractor or implementing partner will:

- Conduct a preliminary logistical assessment to quantify eligible house structures, target population, spray equipment, insecticide, and spray teams and identify suitable sites and facilities for pesticide storage and disposal of effluent waste.
- Develop selected sites for year-round and temporary storage of IRS equipment and insecticide, and construct effluent waste disposal facilities as necessary.
- Identify sensitive areas (water bodies, protected habitat, aquacultural and apicultural activities, etc.) to avoid during IRS.
- Promote acceptance of IRS in the targeted communities through information, education and communication (IEC) activities. Households have the opportunity to “opt-out” of participation in IRS after hearing the IEC messages on benefits and risks.
- Train spray teams in a variety of positions, including site managers, team leaders, spray operators, overalls washers, site attendants, security guards, and water fetchers.
- Procure, transport, and store all necessary spray and personnel protective equipment (PPE), insecticides, and consumables
- Implement the Environmental Mitigation and Monitoring Plan (EMMP) in Annex A of this SEA throughout all processes.

8.1.2 IMPLEMENTING PARTNER REQUIREMENTS:

1. The prime contractor for the project (“the contractor”, or “the PMI IRS implementing partner”) or his designee will develop this SEA that specifies the conditions under which IRS may be implemented.

2. The PMI IRS implementing partner(s) will follow the prescriptions of the EMMP contained herein, including monitoring and reporting to assure appropriate implementation and the sufficiency of environmental compliance measures.

3. The PMI IRS implementing partner(s) shall integrate these environmental compliance measures into the project work plan and report on them in the normal basis of project reporting, including the EMMR Annual Reporting Form and Certification, which will be included in the end-of-spray report (EOSR). The PMI IRS team shall assure that this integration occurs.
4. The PMI IRS implementing partner(s) will ensure that training is provided to all IRS staff and workers as prescribed by the EMMP and USAID’s Automated Directives System (ADS) 204.5.4.

5. The PMI IRS implementing partner(s) will notify PMI/IRS of any work plan activities outside the scope of the SEA, and the PMI unit will independently audit the work plan against the requirements of the SEA.

6. Any activities not addressed within the SEA must be addressed with an SEA amendment that must be approved by the Global Health and Africa Bureau Environmental Officers (BEO) before the activities in question can go forward.

7. The PMI IRS team shall ensure that the contractor’s or PMI IRS implementing partner’s responsibilities with respect to environmental mitigation and monitoring will be incorporated into contracts, grants or any other sub-agreement and scopes of work.

8. For projects currently in implementation, PMI/Mozambique, with the assistance of the Mission Environmental Officer (MEO) and/or the Regional Environmental Advisor (REO) as necessary, will discuss SEA conditions with the contractor; and where necessary, come to appropriate agreement regarding the process for implementing these conditions as a mid-project adjustment.

9. As devising and implementing environmental compliance approaches should be an integral part of work plan development, these procedures place this responsibility principally on prime contractors. PMI IRS team’s primary role is thus to review and monitor, as with the execution of any other part of the work plan. Where such review and monitoring indicates unforeseen environmental impacts or that mitigation and control measures are insufficient, the PMI IRS unit will consult promptly with the Regional Environmental Advisor, to revise and adapt the environmental mitigation measures as necessary.

8.1.3 POLICY, PLANNING AND INSTITUTIONAL REQUIREMENTS

- Prohibit IRS in sensitive ecosystems (i.e. within 30 meters of flood zones, wetlands, National Parks, National Reserves, rivers, dams, lakes, fish farms, beekeeping areas, etc.); IRS uses insecticides that could negatively impact such sites. In line with the established best practices for IRS, and relevant national and USAID policies, the PMI IRS implementing partner will establish and implement mitigation measures to assure adequate protection of these sensitive ecosystems.

- Develop and implement a vector resistance management plan. Appropriate measures will be undertaken to prevent/manage resistance and to ensure the continued effectiveness of insecticides used for IRS.

- Promote inter-sectoral collaboration frameworks and institutional arrangements to facilitate a comprehensive approach to vector control and associated pesticides management. Coordination between the Ministry of Health and major stakeholders will be strengthened. This will include collaboration with:
  - Ministry of Health (MISAU/MOH) National Malaria Control Program (NMCP) is responsible for activities pertaining to the protection and improvement of public health and social welfare. NMCP and Provincial Health Department (DPS) have the mandate to plan, implement and coordinate malaria control activities in Mozambique. The District Health Teams (SDSMA) deal with all diseases including malaria at the district level.
  - The Mozambique Ministry of Coordination of Environmental Affairs (MICOA) is the principle authority for implementing the Framework Environmental Act which provides a legal framework for the use and correct management of the environment and its components and to assure the sustainable development of Mozambique. The Provincial
Department of Environment (DPMA) coordinates environmental management activities at the provincial level.

- MINAGRI, who is responsible for regulating the importation and use of pesticides. It issues permits for the importation of pesticides and implements international conventions governing such pesticides. The use of public health insecticides by the Ministry of Health are generally not regulated by MINAGRI.

- Based on annual resistance testing where pyrethroid and carbamate resistance has been documented, Mozambique used DDT for the 2014 IRS campaign in 10 districts. Most of the districts were in southern Maputo province (Magude, Matutuine, Moamba, Namaacha). Other districts were in northern Maputo (Manhica), Gaza province (Chokwe, Guija), Tete Province (Moatize and Tete city), and Cabo Delgado (Metuge). It is expected that there will be a continued role for DDT in malaria control until equally cost-effective alternatives are developed. DDT (dichlorodiphenyltrichloroethane) is categorized as a persistent organic pollutant (POP); therefore, its management needs to be in accordance to the Stockholm Convention on Persistent Organic Pollutants. Other conventions that regulate DDT management and use include the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. The use of DDT for IRS must be closely monitored and reported to WHO and to the Secretariat of the Stockholm Convention. PMI AIRS Mozambique will assist the GoM as necessary with Stockholm Convention reporting requirements.

- DDT should be used under strict control and only for the intended purpose. Using it in any other way would have important consequences, such as violation of international conventions, and the possible contamination of food and agricultural products, including export goods, with a potential impact on international trade.

- The continued need for DDT should be evaluated regularly by the parties to the Stockholm Convention. The results from these evaluations will depend, among other things, on: insecticide resistance status of local vectors; availability of alternative insecticides; control methods and strategies; and level of funding allocated to malaria vector control.

8.1.4 OPERATIONAL REQUIREMENTS

PMI and the PMI IRS implementing partner will work with MISAU/MOH, MINAGRI and MICOA to access relevant country level authorization and support needed for successful IRS implementation. PMI IRS implementing partner will work closely with NMCP, DPS, SDSMA and DPMA to coordinate and implement the IRS program at the field level. PMI will work with all government partners in the following areas:

- Quality assurance for commodity procurement and IRS operations, to minimize risks to human health and the environment. This will include ensuring legitimate procurement sources, verifiable chain of custody of commodities, and representative sampling and analysis of pesticide, as well as effective quality compliance inspections of IRS activities in the field.

- Ensure compliance with national regulations on pesticides and this SEA EMMP for registering, importing, transporting, labeling, handling, use, storage, and disposal of pesticides. If there is a conflict, this SEA’s EMMP normally has precedence, as it is based on the USAID PMI IRS BMP that was prepared specifically for PMI IRS programs and includes international regulations. USAID compliance requirements are usually more strict than country requirements; however, if country requirements are stricter, they must take precedence.

- Train relevant categories of workers involved in IRS operations (e.g. district program
managers/coordinators, team leaders, spray operators, porters, storekeepers, pesticide transporters/drivers, washpersons, and guards) on best practices in accordance with national pesticides regulations and this SEA (which includes recommendations/guidelines of World Health Organization (WHO). Criteria for reprimanding or punishing non-observance of best practices by these workers will be established.

- Ensure use of appropriate PPE and best practices, including effective field supervision of spray operations, for adequate protection of spray operators and other handlers of pesticides or pesticide-contaminated waste.

- To avoid undue exposure of householders and spray operators to DDT, standard operating procedures and national guidelines should be in place and strictly followed. Appropriate management of DDT also entails adoption and enforcement of stringent rules and regulations to avoid leakage (e.g., into agricultural use) and misuse (e.g., when used in domestic hygiene). This includes the possibility of appropriate legal measures in the event that individuals or entities do not comply with this condition.

- Train health workers in the management of insecticide poisoning. This will include pesticide-specific guidelines on poison treatment; designation of district hospitals or health centers within the target areas for appropriate treatment of insecticide poisoning; training of IRS workers to recognize early danger signs of poisoning and taking appropriate action.

- Enforce protection of fetuses and suckling children against exposure in spray operations. Exclude pregnant women and breast-feeding mothers from direct handling of pesticides (e.g. sprayers or washers). Before each spray season, and every thirty days thereafter during operations, pregnancy testing will be established for potential female handlers of pesticides.

- Work with health extension workers to carry out Information, Education, and Communication (IEC) activities for targeted communities and households to reduce exposure. Provide information on the removal of food, cooking and water utensils, covering of unmovable furniture with impermeable plastic prior to spraying; exclusion of spraying homes inhabited by pregnant women or sick individuals who are unable to leave the structure to be sprayed; preventing the reentry of sprayed rooms for at least two hours after spraying; sweeping of floor residues before reentry of children or animals and disposal cleaning wastes including dead insects in pits or latrines.

- Establish strict practices to reduce environmental contamination from pesticides used in this program. This will include comprehensive pesticide chain of custody, auditing of pesticide stocks and pesticide usage, as well as enforcing best practices related to the handling, washing and disposal of containers; progressive use of waste/wash water and ablution blocks, and training on proper maintenance of spray pumps to prevent leakages.

- Establish best practice for the transport of spray operators. This includes providing trucks with benches for transport of spray operators, and ensuring that insecticides are not transported in the same compartment as spray operators. Contract specific insurance for covering spray operators during spray operation. Strengthen training of drivers to limit risk of traffic accidents.

- Provide IRS Training of Trainers (TOT) and training of spray operators on potential negative impacts of environmental contamination and the appropriate PMI IRS BMPs to avoid or minimize these impacts.

- Provide training support, as necessary, to strengthen the supervisory capacity of MICOA and Provincial Environmental Department (DPMA) at Federal, State and District level for day-to-day monitoring environmental compliance of IRS activities.
8.1.4.1 **Supervisory Structure**

In coordination with the PMI IRS contractor, DPMA will carry out routine compliance inspections of all IRS districts, including unannounced spot inspections, to verify compliance with all relevant national regulations. The PMI IRS contractor will also conduct inspections, including unannounced spot inspections, of IRS activities and facilities in the IRS districts.

The district health management team is composed of the SDSMAS Chief Medical Officer, SDSMAS Health Supervisor, and the District Coordinator (DC). The district team has a strong supervisory role throughout the duration of the spray round. Each district authority supervises the field activities in his/her district to help ensure quality and performance of the spray teams.

The districts are divided into geographical bases to facilitate operation and implementation. Base teams develop their operational plans with support from the DCs and Health Supervisors. Each base designates a Base Supervisor, driver, and 4 teams, each composed of 1 team leader, 4 spray operators and 1 storekeeper. The base teams meet at the beginning and end of each day to discuss operations and share challenges experienced in the field.

The **District Coordinator** ensures the quality of the spray operations and administrative duties. He/she also works in collaboration with the Health Supervisor to manage the planning and coordination of IRS activities. The DC supervises all logistical operations such as store keeping and transportation. And he/she ensures all risk preventions and environmental compliance measures are fully implemented. The District Coordinator and Health Supervisor coordinate all activities. An operational spray plan (progress calendar), produced during the micro-planning and validated by the health team at the district level, indicating all communities to be sprayed during the spray operations will be maintained by the DC. The District Coordinators will hold weekly meetings with the DPS and SDSMAs to discuss operational issues and their solutions. During these meetings, the partners will assess the progress of spray operations, ensure that the planned work schedule is strictly adhered to, and make recommendations as necessary to the IRS project or IEC implementers.

The **Base Supervisor** evaluates the work of the spray teams and IEC activities in the field. He/she also inspects structures that have been sprayed to check quality of spraying and that proper protocols have been fully followed. Base Supervisors will monitor the effectiveness on beneficiary populations of IEC campaigns by visiting sprayed houses to discuss beneficiary impressions, and visiting unsprayed houses to discuss with heads of families why spraying is important. Regarding spray technique and spray operator discipline, monitoring will involve visiting the sprayed compounds and interviewing beneficiaries to ensure that spray operators respect household members, spray all eligible rooms, record the essential data in the relevant form, mix and apply insecticides at the right dosage, and pass the relevant health information to the household. Base Supervisors will provide oversight to ensure the goal of day-to-day achievement of environmental compliance. At the end of each day, team leaders at each operational site will meet with the Base Supervisor to discuss the day’s events, challenges faced, and recommendations for resolving problems.

The **Team Leaders** oversees spray operators to ensure spraying occurs according to best practices. They will also ensure sprayer equipment and PPE are properly cleaned daily, as well as review data collection for accuracy. They are also responsible for tracking insecticide sachets.

The Environmental Compliance Officer will visit each base during the spray operations and complete the Environmental Compliance Checklists. The Environmental Compliance Checklists are versions of those found in the PMI IRS BMP Manual for use in the field. The checklists ensure that all best management practices are being implemented and are effective, or that immediate action is taken to correct non-compliances.
The PMI IRS implementing partner will maintain records of program performance reports which will be able to demonstrate adherence to PMI IRS BMP, quality of training and supervision, procurement activities, and environmental compliance. Such reports include the pre- and mid-spray environmental compliance report (checklist), reports on core IRS indicators and end-of-spray evaluation reports.

Good supervision will also require observing each spray team during implementation to ensure best practices for insecticide storage and solid waste management. Since the reports of the operators are the basis for all reporting and data collection, supervisors will ensure that they are completed accurately and promptly at the end of the spraying day.

8.1.4.2 INSECTICIDE SELECTION

The insecticide selection and the timing of the spray cycle are generally dictated by MISAU/MOH and are based on the results of annual entomological studies. The insecticide will normally be supplied by MISAU/MOH, which is procuring the national need for IRS insecticides with Global Fund support.

8.1.4.3 QUANTIFICATION OF PESTICIDE REQUIREMENTS

Purchase of insufficient pesticide will lead to shortages, delays, and possibly the inability to spray all targeted areas. Purchase of too much pesticide may lead to expiration of the pesticide before it can be used up, which creates serious storage and disposal problems. The PMI IRS implementing partner will conduct an annual geographical reconnaissance and logistics assessment for planning and procurement of materials (insecticides, pumps, PPE, etc.) for all Districts that have been selected by the MISAU/MOH and DPS and where PMI support has been requested.

If it is deemed necessary for the success of the PMI IRS program to supplement MISAU/MOH/Global Fund supplied insecticides, USAID PMI program will procure the insecticide from a reputable supplier. Delivery of all insecticide to the central warehouse will be supervised by PMI and MISAU/MOH before being dispatched to the districts where spray operations will be concentrated. Transportation of insecticides will be done in compliance with program and national environmental compliance requirements.

8.1.4.4 PESTICIDE QUALITY ASSURANCE

The procurement and use of pesticides that do not meet the necessary quality assurance standards can compromise the overall spray quality and desired vector action, while at the same time could expose the residents and spray operators to hazards related to altered toxicological characteristics. All pesticides will be procured from reputable manufacturers who are required to supply data from their own laboratory testing from facilities, and additional in-country testing is not required.

8.1.4.5 QUALIFICATION OF WAREHOUSES (STORAGE FACILITIES)

The procured pesticides are categorized as hazardous and toxic and can potentially cause adverse impacts to human health, animals, and the natural environment if not properly stored. Before insecticides are procured or transported to the spray areas, suitable warehouse(s) must be assessed to ensure that they meet EMMP standards in this SEA. The standards include among others:

- Spacious enough to store insecticides in bulk and to store other materials separately
- Located as far as possible from; flood plains, wetlands, markets, schools and residential areas
- Well ventilated and allowing for air circulation
- Built of concrete or other solid material
- Adequate roofing that is not susceptible to leaks
- Adequately secured with double locks and barred windows
- At least 2 exits for emergency purposes
- Fire extinguisher

During the logistical needs assessment, the PMI IRS implementing partner working with DPS will identify appropriate warehouses at the districts level that meet the above-mentioned requirements. PMI cannot provide funds for the construction of new buildings, but can assist in the modification or renovation of existing facilities. In Mozambique, IRS is implemented in partnership with the DPS, therefore, all warehouses are located on Health Department property for logistic and security purposes.

All facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of the Mozambique MINAGRI Pesticide Regulation, and any other relevant Mozambique standards on pesticides use and management.

### 8.1.4.6 QUALIFICATION OF LIQUID WASTE DISPOSAL FACILITIES (WASH AREAS AND SOAK PITS)

Site considerations for locating IRS cleaning and waste facilities (progressive rinse, soak pits, tanks, and wash areas) include soil type, topography, vertical distance to ground water, and proximity to schools, lakes, streams, and other sensitive areas. Ideally, disposal facilities should be located adjacent to the storage facilities, where they can be more easily protected and monitored. However, the setting or the function of buildings provided for storage do not always lend themselves to siting a wash area, so it may need to be placed some distance away. Due to access limitations and distance of some spray sites, it may be more feasible to locate a small facility in an appropriate area near the spray site.

- Soak pits must be located at least 30 meters from any sensitive areas such as water supplies, habitat, schools, etc. They should be located on relatively high ground to increase the vertical distance to groundwater. The general area should be level, but the wash area must slope gently toward the soak pit or toward the collection point that is piped to the soak pit.

- Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or micro-biological degradation. Clay soils have a high capacity to absorb many pesticides, but if hard-packed, may have limited percolation abilities. Sandy soils have a much lower capacity to absorb pesticides, but liquids percolate rapidly. Where possible, locate facilities on fine textured soils with organic content and good absorptive properties. Hard packed clay or rocky soils are not appropriate.

- Pesticides may move in water runoff as compounds dissolve in water or attach to soil particles. Facilities should be located on high, level ground to minimize exposure to runoff. Avoid steep slopes or natural runoff flow lines. Where feasible, construct curbs or berms to divert runoff away from the soak pit, and to contain any spills. In very rainy areas or seasons, it may be necessary to cover the soak pit/evaporation tank and wash area when not in use with a tarpaulin, to prevent flooding of the soak pit and subsequent runoff of pesticide-contaminated water.

### 8.1.4.7 SUPPLY CHAIN AND DISPOSAL OPTIONS

The PMI IRS implementing partner will work with the relevant authorities and will employ the pesticide chain management as shown in Figure one in its Mozambique IRS programs to ensure control. The chain of custody procedures are based on PMI IRS BMPs (and as previously mentioned, these BMPs include WHO, FAO and other international guidelines).
### Figure 6: Pesticide Chain of Custody and Management

<table>
<thead>
<tr>
<th>Manufacture: Global Fund procures all pesticides for the IRS program. PMI IRS implementing partner supplements pesticides for PMI program as needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imported pesticides: Pesticide samples will be tested for chemical properties and efficacy. Pesticides from an established manufacturer with appropriate laboratory results will not require further tests.</td>
</tr>
<tr>
<td>Port of entry: Pesticides will be collected by PMI staff and MISAU/MOH representative</td>
</tr>
<tr>
<td>Transportation: All drivers must be trained in proper pesticide handling and transportation safety measures as per the PMI IRS BMP. All vehicles must meet BMPs requirements. A PMI and MISAU/MOH representative will escort the pesticide to the central storage facility.</td>
</tr>
<tr>
<td>Central Storage: Pesticide will be stored in warehouses that meet the specifications detail in the FAO manual for storage and transport of pesticides</td>
</tr>
<tr>
<td>Spray Operators must sign out all pesticides received daily and return empty sachets at the end of the day as per the Insecticide Distribution Section below</td>
</tr>
<tr>
<td>District Storage: Empty containers will be stored in warehouses that meet the specification detailed in the FAO manual for storage and transport of pesticides</td>
</tr>
<tr>
<td>Disposal: All empty pesticide sachets will be incinerated in an approved incinerator. All plastic containers will be triple washed and recycled at an approved facility.</td>
</tr>
</tbody>
</table>
8.1.4.8 PESTICIDE TRANSPORT

After the procurement of the insecticides for use during the current IRS campaign, insecticides are expected to move to the district warehouses by road. During transportation, there is a risk of vehicle accidents and consequently insecticide spillage. Accidents have occurred in the past, but no pesticide spillage has occurred to date in PMI Mozambique implementation.

Prior to long-distance transport of the insecticide from the customs warehouse/central storage facility of the supplier, drivers will be informed about general issues surrounding the insecticide and how to handle emergency situations (e.g. road accidents). Training for long-distance transport will include the following information:

- Purpose of the insecticide.
- Toxicity of the insecticide.
- Security issues, including implications of the insecticide getting into the public.
- Hazardous places along the routes to be taken, and mitigation measures.
- Steps to take in case of an accident or emergency (according to FAO standards).
- Combustibility and toxicity of the combustion byproducts of insecticide. Drivers hired specifically for the spray campaign period will receive:
  - Training in operator transportation best practices and vehicle requirements from PMI IRS BMP #2, Worker and Resident Health and Safety.
  - Training provided to spray operators (with the exception of sprayer operation and spray practice).
  - Handling an accident or emergency (according to FAO standards).
  - Handling vehicle contamination.

A lockable box truck is the preferred vehicle to transport insecticides from central to district stores. All vehicles must be in good condition and pass the Pre-Contract Vehicle Inspection performed by the Environmental Compliance Officer or their qualified designate, using a smart phone. If during transport the pesticides are to be left unattended for any period of time, including lunch breaks or overnight stops, a lockable box truck is essential.

Because vehicles used for insecticides transportation can be used for the transport of other goods, including food, it is important to ensure that vehicles are decontaminated. The drivers will be responsible for cleaning and decontaminating the interior of the vehicle and exterior bed at the end of the spray campaign. Drivers will be provided with gloves, overalls, and rubber boots to wear for cleaning the vehicle. All cloths used in wiping down the interior and bed of the vehicle will be washed with soap.
Figure 7: Emergency Response to a Spill

1. Control, contain and clean up the spill
2. Protective clothing should be donned prior to attempting to clean the spills.
3. It is imperative to avoid fire as a result of the accident and a fire extinguisher should be deployed just in case. The engine should be shut off and smoking in the area strictly prohibited.
4. Onlookers and bystanders should be cautioned against approaching the accident site.
5. If the crew has come in contact with the pesticides, they should remove contaminated clothing immediately and wash the pesticide off their skin.
6. For major spills send for help immediately; drivers should have cell phones and an emergency number for use in such cases.
7. People should be kept away and the spill covered with earth, sand, etc.; no attempt should be made to wash away the spill with water or other substances.
8. Vehicles that are used for transporting large quantities of pesticides should be equipped with a bucket of sand, sawdust or soil, a shovel, and fire extinguisher.

8.1.4.9 **Health and Safety in the Warehouse**

The following measures are required in all warehouses in order to reduce cases of pilferage, exposure through leakages and theft, and to ensure the health and safety of those accessing these facilities:

- Guarded 24 hrs/day
- Warehouse must be double-padlocked.
- All the storage facilities must have thermometers installed for temperature recording.
- Soap and clean water for washing must be available at all times.
- Trained storekeepers must be present and wear appropriate PPE when in the pesticide area of storage.
- Pallets are available for proper storage of insecticides
- Pesticide stacking position and height in the warehouses must not be above 2 meters in height.
- Fire extinguishers must be available in the storage facilities and all workers trained on how to use them.
- Hazard warning notices must be placed in the outside of the store in pictorial form (skull and crossbones).
- First-aid kits must be available in all the central warehouses and secondary stores
The PMI IRS implementing partner will use, or develop if necessary, standard requisition, tracking, and monitoring forms to be used for inventory, and record and track all the insecticides distributed and returned. These forms will be used in the program at all levels, and the store managers will receive training on how to use these forms. The steps below highlight the insecticide distribution process proposed including recording and tracking methods:

- Upon reception of the pesticide at the central warehouse (the import company is responsible to deliver the pesticide to a determined location) lot numbers and quantities of insecticide are registered on shelf inventory card by the PMI IRS implementing partner storekeeper. All copies are kept at the warehouse.

- District requisitions are approved at the PMI IRS implementing partner program office, where copies are maintained.

- Requisition then proceeds to district warehouses where distribution takes place. All pesticide inventories are signed for based on sachet numbers. Insecticides are distributed on a “first-in, first-out” system, so the insecticide that arrived first is distributed first. This avoids accumulation of expired stock.

- All sachets are counted and stamped with the relevant stamp and registered on a stock card. Boxes are then resealed with the correct original quantity of sachets inside until the sachets are issued.

- Every morning before the spray operations begin, store managers distribute only enough sachets for the day’s work to the team operators. The team operator must sign for all pesticides received daily in a logbook.

- At the end of the day, empty and full sachets are returned and numbers checked against what was signed out. Returned empty and full sachets are logged into the logbook by the storekeeper or supervisor.

- Supervisor and team leaders examine spray operators’ performance by comparing number of structures sprayed to sachets used to determine whether there is an over or under application.

- Storekeeper must submit the following to the program office for data entry on a daily basis: 1) insecticide stock balances; 2) sign-in/sign-out results; and 3) structures sprayed per spray operator.

- The next day, all previously signed for but unused sachets are reissued and signed for by the relevant spray operator.

- At the end of each day and at the end of the spray round, stock remaining must equal the stock at start of the day minus the number of sachets distributed. Number of sachets distributed should be equal to number of sachets used if there is no returned full sachet.

8.1.4.11 PERSONAL PROTECTIVE EQUIPMENT

In accordance with PMI IRS BMP, all persons working on IRS must be adequately protected against potential harm due to exposure from pesticides. All persons with potential direct contact or exposure to pesticides during handling, transportation, storage, use and cleaning of pesticides or pesticide contaminated materials must wear appropriate personal protective clothing in accordance with the safety instructions on the pesticide label or material safety data sheet (MSDS).

Each team leader, spray operator, and washer for both the district based and community based implementation models will be provided with the following safety equipment to be used during the spraying, in accordance with the PMI IRS BMPs specifications:
• Broad-rimmed hat/helmet
• Face shield or goggles (face shield preferable)
• Dust mask or filtered mask
• Two or more cotton overalls per spray operator (appropriately sized)
• Nitrile rubber, neoprene, or butyl rubber gloves, without inside lining, and long enough to cover the forearm
• Rubber boots
• Cloth to protect the neck.
• Flashlights

For spray operators, safety precautions will depend on the proper use of PPE, and personal hygiene, including washing and daily changing of spray clothes. A schedule for carrying out and supervising personal hygiene, regular washing of protective clothes and cleaning of equipment will be organized along the following lines:

• Spraying staff will be provided with at least two uniforms to allow for frequent changes.
• Washing facilities with sufficient water and soap will be made available in the field at appropriate locations.
• All working clothes must be removed at the end of each day's operations and a shower or bath taken—in circumstances where a full-body shower or bath is not feasible, face/neck and hands must be washed with soap and water.
• Working clothes will be washed daily by the wash-person hired by the project.
• Particular attention will be paid to washing gloves, helmets, face-shields, and boots, and to avoiding contamination of the inside of these items.
• Spray operators will wash before eating, drinking or smoking at the end of the daily spray operation.
• Eating, drinking and smoking during work will be strictly forbidden at all times during operations. If spray operators need to drink water in the course of the operation, they must receive assistance from the homeowner, such that they do not need to handle water containers with gloves or other PPE that has been exposed to pesticides during spray or mixing activities. Because in the field there are no proper disposal facilities for water contaminated by washing gloves and hands, it is recommended that homeowners assist the operator if hydration is needed.

8.1.4.12 PROCUREMENT OF OTHER IRS EQUIPMENT

The following IRS equipment will be procured alongside with the insecticides and PPEs including:

• Spray Nozzles. The program in Mozambique will procure 8002E nozzles for the spray pumps, which are the standard size recommended by WHO for mud and brick walls.
• Spray pumps. Spray operators use Hudson X-PERT or Goizper compression sprayers with shoulder-suspended tanks to apply a measured amount of insecticide on the interior walls of houses and structures. A water-soluble insecticide is added to the sprayer containing a pre-measured amount of water, the sprayer is pressurized, and the material is then applied to the interior walls of targeted house (structure). After the day’s spraying is complete, spray operators must clean the sprayer following the manufacturer’s recommendations to ensure their proper operation and calibration.
The objective of the trainings is to build the capacity of the host government at the national and district levels to implement, monitor and evaluate a well-organized IRS program.

Training in IRS implementation will be a key element of the PMI IRS program. The planning process for trainings will be carried out in coordination with NMCP, and all DPS/SDSMAS malaria officers will be actively engaged from inception. The recruitment and training of spray operators are key elements in this process, and require vigorous involvement of DPS/SDSMAS to ensure that when these activities are transferred to NMCP, there will be sufficient local capacity to continue IRS activities.

**Drivers**

Drivers recruited by the District Coordinator and SDSMAS. Drivers that will transport insecticide will be trained on methods and protocol for safe driving, handling insecticides, and what to do in an emergency situation when transporting insecticides. Drivers will also be trained on insecticide-related security issues, handling vehicle contamination, methods for cleaning vehicles after transporting insecticide, and handling insecticide run-off.

**TOT Training for IRS supervisors:**

Participants include representatives from MOH/DPS/SDSMAS and former trainers from past spray campaigns. Key topics that will be covered include the following:

- Malaria epidemiology
- IRS
- Storage of IRS commodities
- Environmental and Safety issues concerning IRS campaigns
- IEC
- Spray pump use and maintenance
- Spray technique
- Data management and quality (correct use of forms)
- Basic entomological information
- Supervision, performance monitoring and auditing of spray activities

Graduates of the TOT training for supervisors then conduct the spray operator training with the support of the PMI IRS implementing partner. The training has both theoretical and practical sessions.

**Training for District Staff on Environmental Compliance**

Participants will include district health staff identified by the District Coordinator and the Environmental Compliance Officer (ECO). District health staff will be trained on measures taken during IRS operations to meet environmental compliance rules and regulations, based on the EMMP (Annex A). This will include best practices in Environmental Compliance, including pre and post-seaspm inspections/reporting

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps, including practical exercises during a 5-day period prior to the beginning of the spraying campaign. They will also receive training to understand proper hygiene, to recognize the signs and symptoms of poisoning, and to understand the referral procedure for any incidents involving poisoning. This training is conducted in accordance with PMI IRS BMP (which includes WHO IRS guidelines).

**Training spray operators, team leaders and base supervisors:**
Participants include Spray operators, team leaders and base supervisors identified by the DPS and the AIRS Mozambique Operations staff. NMCP, DPS and SDSMAS staff will supervise the trainings sessions.

The training includes:

- Insecticide application technique
- Handling a spray pump
- Communication strategies in the field
- Spray operation organization
- Completing Daily Spray Operator forms for accuracy
- Team Leader protocols for checking Spray Operator data (physical and mathematical checks)
- Use of PPE to prevent toxic exposure, environmental compliance and avoidance of spraying in environmentally-sensitive areas.

Following the training, a post-training exam is given, and only candidates that receive high scores will qualify as spray operators. The DPS will identify outstanding trainees and designate them as team leaders to supervise a number of operators.

Spray operators will initially be chosen based on their completion of primary school and must pass written and practical tests of their ability to read, write and record critical spray information, and make calculations. They will then undergo medical exams to determine their physical capability for providing appropriate application of the insecticide. All female workers will be subjected to a mandatory pregnancy test before training and recruitment as spray operators or washers. Pregnancy tests will then be conducted every month during IRS operations.

Storekeepers

Participants will include storekeepers, MINAGRI and MICOA. Training for all storekeepers includes IRS logistics and supply chain management, insecticide storage and security, inventory tracking (stock card use), spill control and management, and IRS waste storage and management. Following the training, an exam will be given, and only those who achieve a high enough score will qualify as storekeepers for the IRS spray campaign. AIRS Mozambique will work with MINAGRI and MICOA to train storekeepers to manage stock and IRS waste effectively.

Pump technicians

Technicians for each spray “base” will be trained on technical maintenance and repair of the spray pumps and progressive rinsing systems.

Washers

AIRS Mozambique staff will lead a training for washers, on how to wash coveralls and other PPE to prevent contamination.

Data Clerks and District Data Manager

Data clerks will be trained in IRS data entry; using the IRS database; and methods for reviewing data and assuring data accuracy and quality. The M&E Coordinators and Database Manager will complete the trainings.

TOT for IEC Coordinators
Participants will include SDSMAS and IEC Coordinators. Training will include modules on the IEC communication protocol, and messaging for the IEC campaign. The PMI IRS implementing partner with the MOH's Communication department will complete the training.

The main purpose of mobilization is to remind beneficiaries about the positive benefits of IRS in controlling and preventing malaria and malaria-related deaths, and to remind them of their roles and behaviors before, during, and after spray operations. Mobilizers are trained to conduct house-to-house mobilization during the first cycle of each IRS campaign. Once the risks and benefits of IRS have been explained, households have the option of declining to participate.

Door-to-door communication is the main strategy used for community outreach. PMI IRS implementing partner develops, prints, and distributes household IRS cards as well as IRS fliers and brochures with key IRS messages.

**TOT for M&E Coordinators**

The TOT curriculum will consist of IRS data entry; using the IRS database; and methods for reviewing data and assuring data accuracy and quality.

**Health Workers in Poison Management**

Participants include health facility staff identified by the district coordinator and the SDSMAS. The Chief Medical Officers will conduct the trainings. Health facility staff will be trained and prepared for handling insecticide poisonings, skin irritations, and other potential IRS spray campaign injuries. General poison control guidance will be provided. When new pesticides will be used, additional training specific to the symptoms and treatment for that chemical will be provided. Acute exposure can occur through dermal contact, which could lead to absorption into the blood stream as well as skin and eye irritation, inhalation or ingestion. District reference hospitals or health centers will be designated as focal places to handle insecticide poisoning issues and will be provided with antidotes for the pesticides in use (Annexes C & D).
### Figure 8: Treatment Medicines for WHOPES-Recommended Pesticides

<table>
<thead>
<tr>
<th>Pesticide Class</th>
<th>Treatment Medicine(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organochlorine (DDT):</td>
<td>Activated Charcoal (priority)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td></td>
<td>Phenobarbital</td>
</tr>
<tr>
<td></td>
<td>Cholesterylamine resin</td>
</tr>
<tr>
<td>Organophosphates:</td>
<td>Atropine sulfate or Glycopyrolate (priority treatment)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td>Carbamates:</td>
<td>Cholesterylamine Atropine (priority)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam (for seizure)</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>Promethazine</td>
</tr>
<tr>
<td></td>
<td>Panadol</td>
</tr>
<tr>
<td></td>
<td>Diazepam</td>
</tr>
<tr>
<td></td>
<td>Lorazepam</td>
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<tr>
<td></td>
<td>Calamine cream</td>
</tr>
<tr>
<td></td>
<td>Vitamin E</td>
</tr>
<tr>
<td></td>
<td>Hydrocortisone cream</td>
</tr>
<tr>
<td></td>
<td>Salbutamol</td>
</tr>
<tr>
<td>Chlorfenapyr</td>
<td>Activated charcoal</td>
</tr>
<tr>
<td></td>
<td>Benzodiazepine (seizures)</td>
</tr>
</tbody>
</table>

### Accidental Warehouse Fires

Human inhalation of toxic fumes in the event of a storehouse fire is also an unavoidable risk. The risk can be minimized, however, by following PMI IRS BMPs for storage, including prohibiting lighted materials in the warehouse and in the vicinity of pesticides, providing proper ventilation, etc.

Information on the combustion byproducts of pyrethroids can be found in Table 3 below, and the 2012 PEA. Fire-fighting instructions can be found in the Material Safety Data Sheet (MSDS) for the pesticide(s) in storage.
### Table 3: Combustion Byproducts and Firefighting

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Combustion Byproduct</th>
<th>Extinguishing Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha-cypermethrine</strong></td>
<td>Open burning of lambda-cyhalothrin creates nitrogen oxides, hydrogen chloride, and hydrogen fluoride (WHO, 1997)</td>
<td>Extinguishing media: For small fires use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. For large fires, use Alcohol-resistant foam, Water spray. Extinguishing media, which must not be used for safety reasons: Do not use solid water stream as it may scatter and spread fire. Specific hazards during firefighting: As the product contains combustible organic components, fire will produce dense black smoke containing hazardous products of combustion. Exposure to decomposition products may be a hazard to health. Special protective equipment for firefighters: Wear full protective clothing and self-contained breathing apparatus. Further information: Do not allow run-off from fire-fighting to enter drains or watercourses. Cool closed containers exposed to fire with water spray.</td>
</tr>
<tr>
<td><strong>Bendiocarb</strong></td>
<td>Fine dust may form explosive mixtures in air. The product is not flammable, but when heated above 125º C will evolve toxic fumes of methyl isocyanate. Water is the preferred extinguishing medium as it decomposes any methyl isocyanate.</td>
<td>Water fog or fine spray, carbon dioxide, dry chemical, foam. Fire fighters should wear full protective gear, including self-contained breathing apparatus (AS/NZS 1715/1716). Keep unnecessary people away and move all other personnel to windward side of fire. Bund area with sand or earth to prevent contamination of drains or waterways. Dispose of fire control water or other extinguishing agent and spillage safely later.</td>
</tr>
<tr>
<td><strong>Delta-methrine</strong></td>
<td>Combustion and/or pyrolysis of deltamethrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, and hydrogen bromide (UK PID, 2006)</td>
<td>Suitable extinguishing media: Water spray jet, carbon dioxide (CO2), dry powder, foam. Extinguishing media which should not be used for safety reasons: Fire extinguishing measures to suit surroundings.</td>
</tr>
<tr>
<td><strong>Bifenthrin</strong></td>
<td>Not available</td>
<td>Suitable extinguishing media: Carbon dioxide (CO2), Foam; Powders. Not suitable extinguishing media: Water (the product is hazardous for the environment - do not dilute it) Specific fire-fighting methods: Isolate fire area. Evacuate downwind. Contain the extinguishing fluids by bunding (the product is hazardous for the environment). Do not attempt to fight the fire without suitable protective equipment. Do not breathe fumes Protection of fire-fighters: Self-contained breathing apparatus and complete protective clothing.</td>
</tr>
<tr>
<td><strong>Cyfluthrin</strong></td>
<td>Combustion and/or pyrolysis of cyfluthrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, hydrogen chloride, and hydrogen fluoride (UK PID, 2006)</td>
<td>Not available to-date.</td>
</tr>
</tbody>
</table>
8.1.4.14 PREVENTION OF RESIDENTIAL EXPOSURE

The PMI IRS implementing partner and other partners will work with relevant institutions at all levels to carry out an IEC campaign/BCC to sensitize residents to IRS activities. The IEC campaign (as well as IRS Project supervisors and Health Workers, who will also instruct residents on best practices prior to spraying) should focus on the following elements of residential safety during an IRS program:

- Clear homes of mats or rugs, furniture, cooking implements and foodstuffs prior to spraying; if furniture cannot be moved out of the home, then move it to the center of the room and covered with impermeable material.
- Stay outside the home during spraying for two hours after spraying.
- Move and keep all animals outside the home during spraying, and for two hours after spraying.
- After two hours, open all windows and doors and air the house out for ½ hour.
- Sweep up any insects killed from the spraying and drop them in latrine pits.
- Sweep floors free of any residual insecticide that may remain from the spraying and dispose of in pits or latrines.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using bed-nets for protection against malaria.
- If skin itches after re-entrance into home, wash with soap and water; for eye irritation, flush eyes with water; for respiratory irritation, leave the home for fresh air; for ingestion, if soap and water are unavailable, or if symptoms persist, contact program staff or go to nearest health facility which has the appropriate medical intervention.
- If spraying during the rainy season, the teams should follow the following Contingency Plan which will minimize exposure of household effects.

During the rainy season:

- Each spray operator must be given adequate covering material (3m by 3m minimum), which should be used to cover household effects not removed from the houses.
- Adopt a system of moving household effects to the center of the room and covering them with impermeable material, such as a tarpaulin, before spraying.
- Materials can also be moved into structures that are not targeted to be sprayed, e.g., an isolated kitchen or other domestic animal shelter.
- Move the household effects to one room which will not be sprayed on that particular day, but the next day.
- The spray teams should pay close attention to any signs of potential rains so that they prepare the communities accordingly.

When it rains in the mid of spraying:

- Stop the spraying activities. After the rains stop and the weather is considered good spraying can continue.

Cover the household effects with an impermeable material. These materials should have already been procured by the program and given to each operator.
8.1.5  **SPECIAL HEALTH AND SAFETY CONSIDERATIONS WHEN USING DDT**

**8.1.5.1  WORKER HEALTH AND SAFETY**

PPE used for DDT IRS activities should be washed every other day (to minimize contaminated effluent) in a cemented bay that is adjacent to and drains into a storage tank.

**8.1.5.2  PESTICIDE EXPOSURE AND TREATMENT**

Early symptoms may include paresthesia (tingling) of the tongue, lips and parts of the face, which in severe cases extends to the extremities. The patient may have a sense of apprehension and disturbance of equilibrium, dizziness, confusion, and a characteristic tremor. Remove contaminated clothing and wash the affected skin with clean water and soap, and flush the affected area with large quantities of clean water. Keep the patient calm and in quiet, shaded conditions and seek medical attention.

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**Medicines to be Administered by a Professional at the Hospital in Case of DDT Poisoning:**

Activated Charcoal (priority): Phenobarbital.
Diazepam or Lorazepam (for seizure):
Cholestyramine resin.

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8.1.5.3  **SAFETY OF WOMEN SPRAY PERSONNEL**

When using pyrethroids, carbamates, and organophosphates, PMI’s policy is to test all women for pregnancy, and if a woman is found to be pregnant, to only offer positions that do not entail any contact with pesticides. For spray campaigns lasting longer than 30 days, the pregnancy tests must be repeated once every month during the campaign, and to reassign any women found to be pregnant to a position that does not involve potential contact with pesticide. As there is some evidence that DDT is bioaccumulative, and may have an impact on fetal development, it is especially important for countries using DDT to ensure that women are not exposed to DDT. Therefore, if DDT is to be used, women may not occupy positions such as spray operator, washperson, or storekeeper, that have potential contact with DDT.

8.1.5.4  **PESTICIDE STORAGE AND STOCK CONTROL**

It is of increased importance that PMI BMPs regarding pesticide storage and stock control be implemented when using DDT. Strict mechanisms for retrieving empty sachets of DDT from the districts should be established and auditing should be frequent. Once retrieved, the empty sachets will be kept in a secured designated location until transported to a certified incinerator (see solid waste disposal). Punitive measures against pilferage and unauthorized use of DDT should be enforced.
8.2 Preventing Environmental Contamination

8.2.1 Triple Rinse and Reuse of Leftover Pesticide

USAID’s PMI IRS BMP Manual recommends that any remaining pesticide, as well as the water used to rinse out spray pumps at the end of each day must be re-used at the beginning of the next day’s work to save water, reduce the load on soak pits/evaporation tanks (for DDT only), and reduce the potential for pollution from leftover pesticide or contaminated rinse-water. This contaminated material should be considered as make-up water rather than pesticide, as it has degraded with exposure to air and sunlight, and so it must be mixed with new insecticide accordingly. This best practice for spray pump cleaning is called “progressive rinse.” As shown in Figure 11, seven barrels/drums/containers of approximately 200-litres each are placed in a line. Every other container is filled with water (e.g. the first container is empty, the second is filled with water, the third is empty, fourth is filled with water, fifth is empty, sixth is filled with water and the seventh container is empty). During the end-of-day cleanup, the remnants of the insecticide prepared in the field and remaining in the pump are emptied into the first container. This will be a limited volume, which should be much less than half of this container, as most sprayers should be returned empty from the field. It is important to train operators to manage this goal of minimizing leftover at the end of the day. The spray operator will then add two liters of water from the second container, close and shake the sprayer, and dump the rinse water into the third container.

The spray operator will repeat those steps with the fourth and fifth containers, then with the sixth and seventh containers. The spray operator then washes the outside of the sprayer using water from the sixth container on the impermeable wash area that drains to a soak pit. The following day, the spray pumps are filled with liquid from containers in the same sequential order: container one, then container three, then container five, and finally seven.

8.2.2 Liquid Waste Disposal Facilities

Wash Areas and Soak Pits (pyrethroids, carbamates, OPs and chlorfenapyr)

Spray operators must completely wash their pumps, most of their PPE, and themselves after triple-rinsing their pumps. Overalls are washed separately by wash-persons provided with protective gear. In order to minimize possible ground contamination from washing spray equipment and PPE, wash operations are conducted on an impervious (plastic or concrete) wash area that continuously slopes to a soak pit. A soak pit is an in-ground filter that contains a layer of charcoal that adsorbs the insecticide from wash water.

Spray operators should never wash themselves, their overalls, or their PPE in any water bodies, or delay washing until they are home. Washing must be performed at designated sites, and all wash water must be disposed of in a soak pit. Where necessary, construction of infrastructure for proper disposal of contaminated water will be financed by PMI. The site for the soak pits will be selected jointly with the implementing partner’s Operations Manager, Environmental Compliance Officer, District Coordinator and the representative of the District Health Office according to the criteria in 8.1.3.6 The soak pit site must be on high ground away from water bodies, bore holes, schools, and other sensitive areas.

The size of the soak pit depends on the number of spray operators that the soak pit supports. According to the USAID PMI IRS BMP Manual, to serve about 30 operators the soak pits should be 2 meters by 1 meter, excavated to a depth of one meter. The bottom of the pit is packed with sawdust followed by hard coal or charcoal, stone aggregates and gravels as shown in Figure 9. The entire soak pit area is fenced complete with a lockable access door to prevent unauthorized entry by children or animals. Soak pits are built by DPS with funding from PMI. New soak pits are constructed before spray operations commence. Existing soak pits are evaluated by the PMI IRS implementing partner and DPS annually and renovated as needed before spray operations begin.
The soak pit as described can be used for pyrethroids, carbamates, organophosphates and chlorfenapyr. The principle of the soak pit, sometimes referred to as a bio-bed, is to adsorb the toxic chemicals in the pesticide through a carbon filtration process, so that the water that finally exits the bottom of the soak pit has been purified and no longer contains the chemical components in any significant concentration. The gravel and stone layers work to exclude large particulates such as leaves and sticks that may eventually clog the soak pit, and they also help to distribute the influent across the soak pit bed so that it is not concentrated in one spot. As the wash-water flows through the charcoal layer, the organic chemical contaminants (pesticides) are adsorbed onto and held by the charcoal, where they are eventually degraded by environmental forces, including hydrolysis and microbial action. The sawdust at the bottom provides food for the bacterial population, and helps to regulate the flow rate so that there is enough contact time between the contaminated water and the coal. It is believed that pesticides on the coal are degraded within three months in the soak pit. Unless the soak pit becomes clogged with foreign matter and will not drain, the soak pit should remain effective for three years, at which time it can be excavated so that the sawdust and coal can be replaced. As long as the foreign matter can be separated from the stone, the three stone layers can be reconstituted using the same material.

Figure 9: Soak pit layers

Cross section: Soak Pit for Pyrethroids
Showing Filling materials

- Gravels: Size about that for road construction
- Courser gravels/smaller stones
- Stone: Size about average half cement blocks and smaller
- Charcoal: Quantity - about 1.5 - 2.0 max-bags
- Wood shavings/saw dust: Quantity - about 1 - 1.5 max-bags

1.0 m depth

Ground level
Figure 10: Wash area and soak pit schematic

- **7 Progressive Rinse Barrels (200 L)**
- **Wash area**
- **Wash tubs (~15 L) for washing overalls**
- **Soak Pit** - layered with sawdust, charcoal and gravel (see drawing above)
- **Plastic 3-4” pipe or lined, bermed (6”), trench perforating wash area and soak pit curbs, and directing flow to center of soak pit**
- **Raised (10-15 cm) concrete or earthen curb or berm around perimeter of wash area, soak pit, and trench (if pipe is not used between structures).**
Figure 11: Triple rinse system for washing IRS pumps

At the beginning of wash operations

<table>
<thead>
<tr>
<th>Barrel #1</th>
<th>Barrel #2</th>
<th>Barrel #3</th>
<th>Barrel #4</th>
<th>Barrel #5</th>
<th>Barrel #6</th>
<th>Barrel #7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
</tr>
</tbody>
</table>

Wash Operation Sequence

1. Empty leftover pesticide from spray pump. Cap, empty 1st rinse into Barrel #3.
2. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.
3. Depressurize and empty 1st rinse into Barrel #5.
4. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.
5. Depressurize and empty 1st rinse into Barrel #7.
6. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.

Note: After this operation is complete, the outside of the pump is washed, along with the spray operators’ helmet, face shield, gloves, boots, and neck protection, in the central wash area, with the washwater directed to the soak pit.
8.2.3 MOBILE SOAK PITS (MSP)

To reach certain targeted spray areas, operators must travel a great distance, and they may not be able to return at the end of the day to a centralized wash area for clean-up. Sometimes the operators will spend several days in the field, finding lodging and food in the villages where they finish their work for the day. The next day, they either continue to work at the same village, or travel on to the next targeted spray area. Working this way can reduce transportation requirements, shorten the working day, and result in greater productivity. However, operators need a different system for clean-up at the end of the day.

In this situation, the operators carry a MSP filter, wash barrels, and a tarpaulin with them, and construct a temporary wash facility at a suitable site within the village where they will stay. The mobile soak pit filter is a 20-25 L bucket layered as in Figure 12, with highly adsorbent activated carbon that removes pesticide contamination from the wash water, so that the water that exits to the ground is purified.

The MSP can use a four-barrel rinse system to minimize the number of barrels that the spray team must carry, and reduce the necessary size of the wash area constructed. The four-barrel rinse system uses three barrels for rinse water, but only one barrel to receive both the leftover pesticide, and the rinse-water from all three rinses. This system simplifies the reuse of all leftover pesticide and rinse-water the following day, as the operators draw from only one barrel, instead of four. See Figure 13.

Figure 12: Mobile soak pit filter layers
This schematic shows a 4m x 4m (not to scale) wash area with a hole dug in the center of the area to receive the MSP filter. The area is sloped to the MSP filter at the center, and covered with a tarp. An X is cut in the center of the tarp to allow rinse-water to distribute into the MSP. There is a rectangular boot wash at the entrance to the wash area, to collect mud from operators’ boots so that it does not drain to and clog the MSP. There are two rows of rinse barrels so that two operators can wash up at one time. The large barrel on the left receives both leftover pesticide and all rinse-waters. An MSP can only receive rinse waters from washing the outside of the pumps, as well as operators’ PPE, excluding overalls, which are transported to the nearest fixed soak pit and washed. The MSP is sized for 5 operators (1 team), and should not be used for more.

Figure 13: Mobile soak pit configuration

Figure 14: Preparing the site for the MSP installation
8.2.4 Special Considerations for the Disposal of DDT-contaminated Liquids

8.2.4.1 Washwater Disposal

In the implementation of IRS activities, washwater is generated on a daily basis during the cleaning processes for spray pumps, PPE (helmet, face shield, gloves, boots), plastic sheets used to cover household good, and overalls. This wash water is contaminated with very small concentrations of DDT, but improper disposal could cause damage to human health or the environment. Because DDT is a persistent organic pollutant (POP) (meaning that it does not decompose quickly in the environment), even small amounts of discharge could build up to harmful concentrations in the local environment. For this reason, PMI does not use soak pits for the disposal of contaminated wash water. Instead, the washwater is collected and stored for subsequent evaporation or treatment and destruction.

8.2.4.2 Storage and/OR Evaporation Tank

A PMI storage or evaporation tank is designed for the storage of non-biodegradable liquid pesticide waste such as DDT. It can be designed to evaporate the water collected, leaving the solid pesticide behind, or designed to facilitate other means of pumping, capture, treatment, or destruction.

Standard Design and Construction

An IRS holding tank should hold approximately 15,750 liters or 4,100 gallons, which should be sufficient to allow disposal of effluent from 20-30 DDT spray operators during the spray season. If a larger number of operators will be using the facility, it should be designed accordingly. The tank can be designed and engineered to maximize evaporation if that is the separation mechanism, or to accommodate various forms of treatment.

The tank should be constructed with an impermeable surface (e.g., concrete) and covered with a lockable wire mesh on top for physical strength, and a window screen below to exclude bees and other insects. It should be simple to connect a pump for treatment or evacuation.
Figure 15: Evaporation Tank and Wash Bay for DDT Operations

Basic design of evaporation tank and wash bay for DDT-based IRS operations

Estimating volume/size needed: Assume 3.0 - 4.0 liters per person-day. Multiply by # of spray persons and total # of spray days. Add 10% extra volume. The difference could be accommodated by increasing or decreasing depth of tank.

- Evaporation tank (5m x 3m x 0.8 m)
- 0.8 m below natural ground level
- 0.3 m above ground level
- Wash Bay
  - Concrete slab (6m x 4m)
  - Sloping gently towards tank
  - Smooth finish

Note: Top of tank is covered with wire mesh. 0.4 m from edge of tank. Raised edges 20 cm above natural ground. The whole structure will be surrounded with a 1-meter area of gravel.
Siting
Holding tanks should be constructed at least 100 meters away from flood prone areas, steep gradients and slopes, water sources (wells and springs), schools, habitat, protected areas under federal or local regulation. They may not be located within any buffer zone of any protected area. A berm may be required to prevent run-on of stormwater into the tank. The tanks should also be located downhill from the progressive rinse area so that run-off from this facility can be directed into the tank. The wash area must be covered when not in use to prevent overflow of the tank due to collected rainflow.

Precautions
During the spray round, the evaporation tank must be covered with a tarpaulin to prevent rainwater from flooding the tank and causing overflow. If water level in the tank comes within six inches of the drainage hole, liquid should be siphoned into plastic polytanks (around 4k L) for temporary storage, until they can be added back to the tank. Liquid wastes should be placed in double-bung plastic drums or other approved containers.

8.2.4.3 DECOMMISSIONING
After a spray round, the water is removed for treatment or induced to evaporate (while protected from rainfall influent), and all of the sand, sludge, and pesticide residue remaining in the tank is scooped out, placed into a sealed container, stored with empty sachets and other contaminated waste, and disposed of according to US, host-country, and international regulation and conventions. If evaporation is used, the dried residue is carefully collected while wearing full PPE, and is disposed of together with other DDT-contaminated waste. Airborne contamination can be generated during this final cleaning process, so it is essential that PPE is worn, including face shield, gloves, organic/particulate combination respirator, rubber boots, and overalls. This PPE should be wiped clean following use with alcohol-impregnated paper or cloth wipes (e.g., baby-wipes), which are also added to the contaminated waste.
For final decommissioning, the tank should be cleaned with a towel dampened with alcohol, which is then added to the residue container. All this hazardous waste must be disposed of according to all US and host-country regulations and international conventions regarding POPs and hazardous wastes.

Concrete storage or evaporation tanks should be broken up and buried in a secure location, or used as road bed material. The site should be restored back to its natural state as much as possible. Sampling and analysis of site soil and vegetation should be performed to ensure that DDT concentrations do not significantly exceed ambient concentrations in more distant surrounding soils.

DDT-contaminated solid waste must be sent to an incinerator that meets Basel Convention technical standards for POP destruction. See more complete instructions below. Considering the available facilities in Mozambique, DDT waste will likely need to be shipped to an appropriate incinerator in another country. After incineration the remaining ash residue should be handled as a dangerous material. Mixing this ash with concrete for use in construction or roadbuilding is one of the safest and most useful methods of final disposal.

All wash-persons at the evaporation tank staging area will wear gloves, boots, and coveralls, and will wash overalls at the operational site while spray operators are in the field. Spray operators must completely wash themselves after each day's operations using washbasins or shower areas constructed near the soak pits. Spray operators should never wash themselves, their overalls, or their PPE in any water bodies, or delay washing until they are home. Washing must be performed at designated sites, and all wash-water must be disposed of in the evaporation or storage tank.

### 8.2.5 IRS SOLID WASTES DISPOSAL

IRS solid wastes must be classified as contaminated with insecticide, or non-contaminated, according to the guidance below. Contaminated solid wastes should be stored with pesticide stocks, separated from non-contaminated wastes and IRS commodities. At the local site level, contaminated solid wastes are separately collected, counted, and stored in labeled and sealed boxes. Unusable gloves, plastic bags, boots and plastic sheeting are washed with soap and water, air-dried and packaged by washers in closed containers. All such decontaminated solid wastes are then transferred to the main warehouse in Quelimane, where decontaminated gloves are disposed of properly as ordinary garbage, and decontaminated plastic wastes are recycled in facilities approved by MICOA.

Contaminated wastes, including empty insecticide sachets, plastic pesticide containers, and masks, will be temporarily stored in the District warehouses. At the end of the spray campaign, the material will be relocated to the central storage facility in Quelimane (or other district capital if PMI IRS activities expand or move to other districts). All contaminated material will require disposal in an environmentally responsible manner as prescribed by the PMI IRS BMPs.

For mask and sachet disposal, as well as other contaminated wastes that cannot be cleaned with soap and water, incineration under specific conditions is highly recommended by PMI, the United Nations Environment Program (UNEP) and WHO/FAO. Incinerators recommended for disposal of (non-DDT) contaminated wastes must meet the following key requirements:

- The recommended combustion temperature is between 1,100°C and 1,300°C.
- An after-burner is required, with a residence time of at least two seconds.
- The incinerator should have emission control, including particulate matter filters.
- Ash and slag produced by high-temperature incineration of pesticides are best incorporated into concrete and buried in a secure location. In Mozambique, as solid wastes are not incinerated in a PMI-owned incinerator and the implementing partner does not have control over the ash and slag, PMI AIRS can only recommend this disposition.
Incineration is not recommended for polyvinyl chloride or other chlorinated wastes such as gloves and boots, because of the potential for dioxin generation. Gloves and boots no longer usable for IRS can be easily decontaminated with soap and water and offered to spray team members, or disposed of as normal non-hazardous waste.

Empty plastic containers should not be incinerated due to the difficulty inherent in burning them cleanly, and the nuisance and toxic emissions that may result. Once punctured to prevent reuse, plastic bottles can be triple rinsed and recycled at an appropriate facility, or landfilled.

Cardboard boxes previously containing intact insecticide sachets or bottles are not considered as contaminated waste unless visibly contaminated. Incineration is not recommended for cardboard boxes unless they have been contaminated by pesticide leakage, or used for the storage of other contaminated wastes. In many cases uncontaminated boxes can be recycled by industries such as pulp for newspaper or card stock manufacture, or can also be disposed of as normal non-hazardous wastes.

8.2.6 Special Considerations for DDT-Contaminated Solid Waste Disposal

Contaminated DDT solid waste is generated during the implementation of IRS activities in the form of respirator cartridges, empty pesticide sachets, damaged PPE equipment, used cleaning equipment, and materials such as contaminated soil from accidental spills, sawdust used to clean up spills, storage tank residue, and expired pesticides. These substances pose health and environmental hazards, and should be incinerated in an incinerator that meets Basel Convention technical standards for DDT disposal, as well as WHO and FAO guidelines.

DDT-contaminated wastes will only be disposed of under the following conditions (drawn from WHO and FAO guidelines):

1. Commercially licensed facilities accredited by the host governments to dispose of POP toxic waste. The IP or the GoM must obtain a list of the approved and licensed facilities from the environmental agencies/authorities. If there are no appropriate in-country incinerators, the GoM or the IP must locate and contract with an appropriate facility outside of the country.

2. Facilities must be assessed by the IP and found to satisfy PMI and international requirements for toxic waste disposal.

3. Incinerators constructed or procured by the implementing partner that meet international standards (WHO/FAO).

4. Incinerators that consistently burn between 1100 deg. C and 1300 deg. C, with a minimum 2 second residence time in the afterburner chamber (hot zone) with excess oxygen (>11%) and with high levels of induced turbulence in the gas stream to promote complete combustion. The gas stream is then rapidly cooled to eliminate the risk of dioxin and furan formation.

5. Incinerators with air scrubbers to ensure minimal impact to air quality.

6. In some cases incineration can be negotiated with the pesticide manufacturers, who are responsible for recapturing solid wastes and then disposing of those wastes in an environmentally sound manner.

7. Alternatively, cement kilns or furnaces can also be considered for disposal in countries where cement factories or copper furnaces that meet the above criteria are available.

Wastes consisting of, containing, or contaminated with DDT should be properly packaged before storage or transport. Empty containers should be punctured to ensure that they cannot be used for other purposes, particularly the storage of food or water for human or animal consumption. Ideally
The main concerns when handling DDT contaminated wastes are human exposure, accidental release to the environment, and contamination of other waste streams with DDT. Such wastes must be handled separately from other waste types to prevent contamination of other waste streams.

All DDT wastes are considered hazardous wastes and must be properly disposed of. DDT solid waste can be disposed of in an approved incinerator that meets DDT disposal requirements. As no such incinerator currently exists in Mozambique, the waste must be transported out of the country to a certified facility. This can be complicated due to inter-country transport/export/import laws, and must meet Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal requirements as there are stringent requirements for notice, consent and tracking for movement of wastes across national boundaries. Once incinerated, the remaining ash residue from the incineration must be treated as toxic waste and be disposed according to the requirements for disposal of toxic ash residue. Because of the small number of qualified incinerators worldwide, PMI AIRS will be unlikely to have control over the disposal of ash from the incineration of DDT wastes.

The use of DDT is subject to the following additional requirements:

- Notify Stockholm Secretariat and WHO of production and/or use of DDT
- Restrict production and/or use to disease vector control
- Produce and/or use DDT in accordance with WHO recommendations and guidelines
- Use DDT only when locally safe, effective, and affordable alternatives are not available
- Report on production and/or use of DDT every three years (reporting requirements found at www.pops.int).

Stockholm Convention Recommendations on DDT

The Stockholm Convention also lays out the following recommendations, “with the goal of reducing and ultimately eliminating the use of DDT”:

- Each Party using DDT should develop and implement an action plan as part of its National Implementation Plan (NIP). That action plan should include:
  a) Development of regulatory and other mechanisms to ensure that DDT use is restricted to disease vector control
  b) Implementation of suitable alternative products, methods, and strategies, including resistance management strategies to ensure the continuing effectiveness of these alternatives
  c) Measures to strengthen health care and to reduce the incidence of the disease.

- All Parties to the Stockholm Convention, within their capabilities, should promote research and development of safe alternative chemical and nonchemical products, methods, and strategies for vector control

As a signatory to the Stockholm Convention, the U.S. Government is committed to ensuring that its support for DDT use in developing countries is consistent with
Stockholm Convention requirements and recommendations, as well as NIPs prepared by the host countries. Thus, USAID will support the following planning, program, and environmental compliance activities where it supports DDT use in disease vector control:

- USAID will base its support of insecticides used in disease vector control on a rational selection process considering the insecticide’s effectiveness in reducing or repelling the vector; risk to human health, the environment, and the agricultural and trade sectors; acceptability in the host country; cost; the need for resistance management; and other considerations.

- USAID will only provide support of DDT to Parties that have notified the Stockholm Secretariat and the WHO of their production and/or use of DDT, and that restrict DDT use to disease vector control.

- All USAID support of DDT use will follow WHO recommendations and guidelines.

- USAID will assist host-country governments in re-examining the need for DDT based upon the best available information and in identifying the best choice for IRS chemicals, considering safety, effectiveness, and affordability in accordance with the Stockholm Convention. The selection of alternatives or combination of alternatives for malaria control will take into consideration human health risks and environmental implications; viable alternatives to DDT should pose less risk to human health and the environment, be suitable for disease control, and be supported with monitoring data.

- USAID will review and revise SEAs pertaining to DDT every year, to ensure that USAID support remains consistent with stipulations in the Stockholm Convention, the host-country NIP, and Stockholm Convention Party reporting requirements for DDT use.

- When local capacity is insufficient, USAID will assist host-country governments in conducting activities to fulfill Stockholm Convention reporting requirements. To receive USAID support for use of DDT in IRS, the host country must demonstrate concerted effort in developing and following a NIP as well as reporting to the Stockholm Secretariat.

- USAID will support the monitoring of DDT in the environments where it is sprayed. According to CFR Title 22 Section 216, “to the extent feasible and relevant, projects and programs for which Environmental Impact Statements or Environmental Assessments have been prepared should be designed to include measurement of any changes in environmental quality, positive or negative, during their implementation.”

- When local capacity is insufficient, USAID will facilitate appropriate disposal of DDT-contaminated waste resulting from IRS operations in accordance with the Basel Convention and other relevant regional and international treaties.

8.3 CONCLUSION

Using the foregoing Best Management Practices and procedures, IRS can be performed safely and provide substantial benefits to the beneficiaries. The EMMR Annual Reporting Form in Annex A will be submitted to USAID as part of the annual end-of-spray report.
9. **EMMP Implementation**

The DPS, DPMA, and PMI IRS implementing partner, along with support from MISAU/MOH, MINAGRI and MICOA, will be responsible for implementation of the EMMP. The staff in charge of implementation of EMMP will be trained to ensure effectiveness of the mitigation measures during spray operation. The DPS and DPMA officers, and the implementing partner Environmental Compliance Officer will monitor environmental compliance during the IRS campaign.

The PMI IRS implementing partner will work closely with DPS and DPMA throughout the spray campaign. The PMI IRS implementing partner’s Environmental Compliance Officer will conduct environmental compliance inspections during pre-spray activities, during mid-spray operations and at the completion of the spray campaign. These inspections will endeavor to ensure that all the mitigation measures in the EMMP are being implemented and propose measures for improvement for the next IRS campaign. These compliance inspections achieve the following objectives:

- Observe IRS activities in progress to determine and document whether the intervention is in full compliance with USAID requirements as included in the approved SEA.
- Create a baseline of current compliance status for the purpose of evaluating improvement in future IRS programs.
- Ensure adherence to relevant international rules and regulations, including USA regulations.
- Ensure that all persons in potential contact with pesticides use PPE at all times.
- Ensure accurate record keeping and daily collection of empty sachets.
- Ensure that progressive rinsing methods are used in all spray sites and ensure that leftover insecticide solution is re-used for spraying the next day to prevent environmental contamination.
- Ensure that spray operators, washers, team leaders and supervisors are knowledgeable of the correct way to handle and apply insecticides.
- Determine, in consultation with DPS and DPMA officials, the training and support required to improve and ensure future compliance with the SEA.

If support is provided for the use of DDT to: i. procure/loan/dispose of spray pumps and PPE; ii. provide TOT or lower level trainings, or; iii. build evaporation tanks, the following conditions must be met:

- Include such activities in an SEA or amendment (SEA amendments for DDT are done on an annual basis)
- Provide environmental training in IRS BMPs (USAID and/or USAID IP)
- Perform annual environmental compliance monitoring (USAID and/or USAID IP)
- Design and implement a sampling and analysis program to provide baseline and ongoing monitoring data on soil and plant DDT concentrations in the vicinity of operations sites.

In addition, PMI has annually-programmed funds to conduct an independent environment compliance audit to ensure that all the mitigation measures are implemented during the spray campaign.
10. PUBLIC CONSULTATIONS

During the preparation of this SEA, consultations with the implementing governmental agencies including the MISAU/MOH, MICOA, MINAGRI and the USAID Mission PMI staff were conducted at the central level. Also, consultations with the provincial level malaria and environmental programs (DPS and DPMA) for all ten provinces were undertaken to ensure the information provided in this document was accurate and meets the needs of the PMI Mozambique malaria control program for the next five years. The SEA also sets out to meet the needs of the Mozambique Environmental Impact Assessment requirements.

PMI includes public consultations through Information, Education and Communication (IEC) as a vital part of the IRS implementation process. IEC comprises information education as well as communication concepts. This kind of communication is vital to IRS, to ensure high levels of community and household participation, safety, and long-lasting impact of spraying.

IRS IEC activities are led by the DPS through the SDSMAS IEC Coordinators. An IEC mobilization campaign will be conducted before and during spraying operations. At least two orientation meetings will be held at the community level. The rationale is to have community leaders involved in IRS planning activities at the community level. Additionally, community leaders will play an important role to stimulate behavior change and ensure community adherence to IRS, which in turn will mitigate refusals among households.

The SDSMAS IEC Coordinators will sensitize the target communities, raise awareness on IRS as a malaria prevention strategy, increase acceptance, and mobilize program beneficiaries to participate in IRS activities by informing them of their roles before, during and after the spray operations.

At the discretion of the PMI program, a draft version of the SEA will be distributed to the malaria control partners in Mozambique for review.
## ANNEX A: ENVIRONMENTAL MITIGATION AND MONITORING PLAN

<table>
<thead>
<tr>
<th>Category of Activity</th>
<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
<th>Monitoring Indicator</th>
<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of insecticides</td>
<td>1. Occupational risks for workers involved in IRS campaigns (e.g., risks from insecticide exposure and vehicular accidents), especially women of child-bearing age</td>
<td>a. Inspect and certify vehicles used for pesticide or spray team transport prior to contract. b. Train drivers c. Provide cell phone, personal protective equipment (PPE) and spill kits during pesticide transportation. d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact. e. Health test all spray team members for duty fitness. f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE. g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps. h. Provide adequate facilities and supplies for end-of-day cleanup. i. Enforce spray and clean-up procedures.</td>
<td>a-d. Environmental Compliance Officer (ECO). e-g. Operations Manager (OM). h. ECO i. Chief of Party (COP), Technical Project Managers (TPM) and headquarters environmental staff.</td>
<td>a. Transport vehicles have a valid inspection certificate on-board. b. Drivers have a certificate of training completion. c. Transport vehicles are equipped with cell phone, spill kit, and PPE. d. Storekeeper has records of pregnancy testing for all female team members. e. Storekeeper has medical exam results for all team members. f. Spray operators wear complete PPE during spraying and clean-up. g. Operators mix pesticide properly, and the pump does not leak. h. All facilities are compliant, and materials required for clean-up are present. i. Inspections are performed as scheduled, corrective action is taken as needed.</td>
<td>a-c. ECO inspection of vehicles in the field. d-e. ECO inspection of health records at IRS operational sites. f-h. ECO performs pre-spray inspections of inventories and training records, and mid-spray inspections of PPE use and spray operator performance. i. Monitoring of on-line database for submission of inspection reports.</td>
</tr>
<tr>
<td>Category of Activity</td>
<td>Describe specific environmental threats of your organization's activities</td>
<td>Description of Mitigation Measures</td>
<td>Who is responsible for monitoring</td>
<td>Monitoring Indicator</td>
<td>Monitoring Method</td>
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</table>
| 2. Safety risks for residents of sprayed houses (e.g., risks from inhalation and ingestion of insecticides) | a. IEC campaigns to inform homeowners of responsibilities and precautions.  
   b. Prohibit spraying houses that are not properly prepared.  
   c. Two-hour exclusion from house after spraying  
   d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside. | a-b. IEC officers, OM, ECO  
   c. ECO  
   d. Spray operators (SO) and Team Leaders (TL) | a. Pre-spray IEC campaigns were executed. Homeowners know responsibilities.  
   b. All houses being sprayed are properly prepared.  
   c. Homeowners observe 2 hour exclusion.  
   d. Lack of incident reports, or incident reports with proper response noted. | a. OM- IEC work records,  
   ECO- mid-spray inspections.  
   b-d. ECO mid-spray inspections | | |
| 3. Ecological risk to non-target species and water bodies from use of insecticides (during mixing and spraying) | a. Spray indoors only.  
   b. Train operators on proper spray technique.  
   c. Maintain pumps.  
   d. Design and implement sampling program to provide baseline and ongoing monitoring on soil and plant DDT concentrations in the vicinity of operations. | a-c. TL, District Coordinator (DC), OM, ECO | a. Operators spray only inside of houses.  
   b. Operators are trained and know and use proper spray techniques.  
   c. Pumps are maintained and operated to eliminate leaks and erratic spraying. | a. ECO mid-spray inspections.  
   b-c. Training records, ECO mid-spray inspections | | |

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<table>
<thead>
<tr>
<th>Category of Activity</th>
<th>Describe specific environmental threats of your organization’s activities</th>
<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
<th>Monitoring Indicator</th>
<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
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</table>
| 4. Environmental risk from disposal of insecticide (both liquid and solid waste) | **a. Choose sites for disposal of liquid wastes according to PMI BMPs.**  
**b. Construct soak pits with charcoal to adsorb pesticide from rinse water.**  
**c. Maintain soak pits as necessary during season.**  
**d. Inspect and certify solid waste disposal sites before spray campaign.**  
**e. Monitor waste storage and management during campaign.**  
**f. Monitor disposal procedures post-campaign.**  
**g. PMI AIRS will assist the GoM as necessary with Stockholm Convention reporting requirements.** | a-c. Abt OM, ECO, DC  
b. Soak pits are constructed according to the PMI BMP manual.  
c. Soak pits perform properly throughout the spray season.  
d. Disposal sites have the capacity and policies to properly dispose of wastes.  
e. Wastes are stored and managed according to PMI BMPs.  
f. Waste disposal sites has taken place as agreed and certificates of disposal received. | a-b. ECO Pre-spray inspections  
c-f. ECO mid- and post-spray inspections and monitoring. | a-b/campaign  
b/1/campaign  
c/5/week  
d/1/campaign  
e/3/week  
f. Continuous during disposal |
| 5. Risk of diversion of insecticides for unintended or uncontrolled use | **a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.**  
**b. Reconcile number of houses sprayed vs. number of sachets/bottles used.**  
**c. Examine houses sprayed to confirm spray application.**  
**d. Perform physical inventory counts during the spray season.** | a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO | a-d. All pesticide management records are reconciled. | a-b, d. Inspection of pesticide management records. Storekeeper performance checklists.  
c. ECO mid-spray inspections. | a-b, d. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District Coordinators  
c. 1/campaign by country headquarters.  
2/campaign by ECO  
d. 2/campaign/ store-room |
ANNEX B: EMMR FORM

Please see Annual Environmental Mitigation and Monitoring Report (EMMR) Form next page
### Mitigation Measure

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>Status of Mitigation Measures</th>
<th>Outstanding issues relating to required conditions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport.</td>
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<td>1b. Driver training</td>
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<tr>
<td>1c. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation.</td>
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<td>1d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.</td>
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<td>Mitigation Measure</td>
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<td>1e. Health fitness testing for all operators</td>
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<td>1f. Procurement of, distribution to, and training on the use of PPE for all workers with potential pesticide contact.</td>
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<td>1g. Training on mixing pesticides and the proper use and maintenance of spray pumps.</td>
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<tr>
<td>1h. Provision of adequate facilities and supplies for end-of-day cleanup,</td>
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<tr>
<td>1i. Enforce spray and clean-up procedures.</td>
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<tr>
<td>2a. IEC campaigns to inform homeowners of responsibilities and precautions.</td>
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<tr>
<td>2b. Prohibition of spraying houses that are not properly prepared.</td>
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<td>2c. Two-hour exclusion from house after spraying</td>
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<tr>
<td>2d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside.</td>
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<tr>
<td>3a. Indoor spraying only.</td>
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<tr>
<td>3b. Training on proper spray technique</td>
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<tr>
<td>3c. Maintenance of pumps</td>
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<tr>
<td>4a. Choose sites for disposal of liquid wastes according to PMI BMPs.</td>
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<tr>
<td>4b. Construct soak pits with charcoal to adsorb pesticide from rinse water.</td>
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<tr>
<td>4c. Maintain soak pits as necessary during season.</td>
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<tr>
<td>4d. Inspection and certification of solid waste disposal sites before spray campaign.</td>
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<tr>
<td>4e. Monitoring waste storage and management during campaign.</td>
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<tr>
<td>4f. Monitoring disposal procedures post-campaign.</td>
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<tr>
<td>5a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</td>
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<tr>
<td>5b. Reconciliation of number of houses sprayed vs. number of sachets/bottles used.</td>
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<tr>
<td>5c. Visual examination of houses sprayed to confirm pesticide application.</td>
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<tr>
<td>5d. Perform physical inventory counts during the spray season.</td>
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</table>
Skin Decontamination

Decontamination must proceed concurrently with whatever resuscitative and antidotal measures are necessary to preserve life. Shower patient with soap and water, and shampoo hair to remove chemicals from skin and hair. If there are any indications of weakness, ataxia, or other neurologic impairment, remove the victim’s clothing, have the victim lie down, and give the victim a complete bath and shampoo using copious amounts of soap and water. Check for pesticide sequestered under fingernails or in skin folds and wash these areas.

Flush contaminating chemicals from eyes with copious amounts of clean water for 10-15 minutes. If eye irritation is present after decontamination, ophthalmologic consultation is appropriate.

Persons attending the victim should avoid direct contact with heavily contaminated clothing and vomitus. Contaminated clothing should be promptly removed, bagged, and laundered before returning to the patient. Shoes and other leather items cannot usually be decontaminated and should be discarded. Note that pesticides can contaminate the inside surfaces of gloves, boots, and headgear. Decontamination should especially be considered for emergency personnel (such as ambulance drivers) at the site of a spill or contamination. Wear rubber gloves while washing pesticide from skin and hair of patient. Latex and other surgical or precautionary gloves usually do not provide adequate protection from pesticide contamination.

Airway Protection

Ensure that a clear airway exists. Suction any oral secretions using a large bore suction device if necessary. Intubate the trachea if the patient has respiratory depression or if the patient appears obtunded or otherwise neurologically impaired. Administer oxygen as necessary to maintain adequate tissue oxygenation. In severe poisonings, mechanically supporting pulmonary ventilation for several days may be necessary.

Note on Specific Pesticides: There are several special considerations with regard to certain pesticides. In OP and carbamate poisoning, adequate tissue oxygenation is essential prior to administering atropine.

Gastrointestinal Decontamination

A joint position statement has recently been released by the American Academy of Clinical Toxicology and the European Association of Poisons Centres and Clinical Toxicologists on various methods of gastrointestinal decontamination. A summary of the position statement accompanies the description of each procedure.
1. **Gastric Lavage.** If the patient presents within 60 minutes of ingestion, lavage may be considered. Insert an orogastric tube and follow with fluid, usually normal saline. Aspirate back the fluid in an attempt to remove any toxicant. If the patient is neurologically impaired, airway protection with a cuffed endotracheal tube is indicated prior to gastric lavage. Lavage performed more than 60 minutes after ingestion has not proven to be beneficial and runs the risk of inducing bleeding, perforation, or scarring due to additional trauma to already traumatized tissues. It is almost always necessary first to control seizures before attempting gastric lavage or any other method of GI decontamination. Studies of poison recovery have been performed mainly with solid material such as pills. There are no controlled studies of pesticide recovery by these methods. Reported recovery of material at 60 minutes in several studies was 8 percent to 32 percent. There is further evidence that lavage may propel the material into the small bowel, thus increasing absorption.

**Note on Specific Pesticides:** Lavage is contraindicated in hydrocarbon ingestion, a common vehicle in many pesticide formulations.

**Position Statement:** Gastric lavage should not be routinely used in the management of poisons. Lavage is indicated only when a patient has ingested a potentially life-threatening amount of poison and the procedure can be done within 60 minutes of ingestion. Even then, clinical benefit has not been confirmed in controlled studies.

2. **Activated Charcoal Adsorption.** Activated charcoal is an effective absorbent for many poisonings. Volunteer studies suggest that it will reduce the amount of poison absorbed if given within 60 minutes. There are insufficient data to support or exclude its use if time from ingestion is prolonged, although some poisons that are less soluble may be absorbed beyond 60 minutes. Clinical trials with charcoal have been done with poisons other than pesticides. There is some evidence that paraquat is well absorbed by activated charcoal. Charcoal has been anecdotally successful with other pesticides.

**DOSAGE OF ACTIVATED CHARCOAL:**

- Adults and children over 12 years: 25-100 g in 300-800 mL water.
- Children under 12 years: 25-50 g per dose.
- Infants and toddlers under 20 kg: 1 g per kg body weight.

Many activated charcoal formulations come premixed with sorbitol. Avoid giving more than one dose of sorbitol as a cathartic in infants and children due to the risk of rapid shifts of intravascular fluid. Encourage the victim to swallow the adsorbent even though spontaneous vomiting continues. Antiemetic therapy may help control vomiting in adults or older children. As an alternative, activated charcoal may be administered through an orogastric tube or diluted with water and administered slowly through a nasogastric tube. Repeated administration of charcoal or other absorbent every 2-4 hours may be beneficial in both children and adults, but use of a cathartic such as sorbitol should be avoided after the first dose. Repeated doses of activated charcoal should not be administered if the gut is atonic. The use of charcoal without airway protection is contraindicated in the neurologically impaired patient.

**Note on Specific Pesticides:** The use of charcoal without airway protection should be used with caution in poisons such as OPs, carbamates, and organochlorines if they are prepared in a hydrocarbon solution.

**Position Statement:** Single-dose activated charcoal should not be used routinely in the management of poisoned patients. Charcoal appears to be most effective within 60 minutes of ingestion and may be considered for use for this time period. Although it may be considered 60 minutes after ingestion, there
is insufficient evidence to support or deny its use for this time period. Despite improved binding of poisons within 60 minutes, only one study suggests that there is improved clinical outcome. Activated charcoal is contraindicated in an unprotected airway, a GI tract not anatomically intact, and when charcoal therapy may increase the risk of aspiration of a hydrocarbon-based pesticide.

**Seizures:** Lorazepam is increasingly being recognized as the drug of choice for status epilepticus, although there are few reports of its use with certain pesticides. Emergency personnel must be prepared to assist ventilation with lorazepam and any other medication used to control seizures. See dosage table below. For organochlorine compounds, use of lorazepam has not been reported in the literature. Diazepam is often used for this, and is still used in other pesticide poisonings.

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**DOSAGE OF DIAZEPAM:**

- **Adults:** 5-10 mg IV and repeat every 5-10 minutes to maximum of 30 mg.
- **Children:** 0.2 to 0.5 mg/kg every 5 minutes to maximum of 10 mg in children over 5 years, and maximum of 5 mg in children under 5 years.

**DOSAGE OF LORAZEPAM:**

- **Adults:** 2-4 mg/dose given IV over 2-5 minutes. Repeat if necessary to a maximum of 8 mg in a 12 hour period.
- **Adolescents:** Same as adult dose, except maximum dose is 4 mg.
- **Children under 12 years:** 0.05-0.10 mg/kg IV over 2-5 minutes. Repeat if necessary .05 mg/kg 10-15 minutes after first dose, with a maximum dose of 4 mg.

Caution: Be prepared to assist pulmonary ventilation mechanically if respiration is depressed, to intubate the trachea if laryngospasm occurs, and to counteract hypotensive reactions.

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Phenobarbital is an additional treatment option for seizure control. Dosage for **infants, children, and adults** is 15-20 mg/kg as an IV loading dose. An additional 5 mg/kg IV may be given every 15-30 minutes to a maximum of 30 mg/kg. The drug should be pushed no faster than 1 mg/kg/minute.

For seizure management, most patients respond well to usual management consisting of benzodiazepines, or phenytoin and phenobarbital.
## Annex D: Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Organochlorines

<table>
<thead>
<tr>
<th>Organochlorines</th>
<th>Human side effects</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>DDT</td>
<td>DDT impairs the conduction of nerve impulses. In humans, this can cause effects ranging from mild altered sensations to tremors, convulsions, and respiratory depression. Additional effects observed in humans following acute DDT exposure include headaches; nausea; vomiting; diarrhea; numbness; paresthesia; increased liver enzyme activity; irritation of the eyes, nose, or throat; altered gait; and malaise or excitability.</td>
<td>Exposure to DDT may be measured through laboratory tests. DDT and its metabolites (DDE and DDD) may be detected in the blood/plasma, semen, urine, liver, kidney, fatty tissue, skin lipids, breast milk, and lymphatic tissues. DDT exposure should be treated with anticonvulsants (benzodiazepines), oxygen, and cardiopulmonary monitoring. Epinephrine, other adrenergic amines, atropine, and orally administered fats are all contraindicated.</td>
</tr>
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</table>
### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Carbamates

<table>
<thead>
<tr>
<th>Carbamates</th>
<th>Human side effects</th>
<th>Treatment</th>
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</thead>
<tbody>
<tr>
<td>Bendiocarb</td>
<td>Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.</td>
<td>The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.</td>
</tr>
<tr>
<td>Propoxur</td>
<td>Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.</td>
<td>The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.</td>
</tr>
</tbody>
</table>
### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Organophosphates

<table>
<thead>
<tr>
<th>Organophosphates</th>
<th>Human side effects</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>Malathion</td>
<td>Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase in the blood and brain. Exposure to high levels can result in difficulty breathing, vomiting, blurred vision, increased salivation and perspiration, headaches, and dizziness. Loss of consciousness and death may follow very high exposures to malathion.</td>
<td>Oral exposure to malathion should be treated with rapid gastric lavage unless the patient is vomiting. Dermal exposures should be treated by washing the affected area with soap and water. If the eyes have been exposed to malathion, flush them with saline or water. People exposed to malathion who exhibit respiratory inefficiency with peripheral symptoms should be treated via slow intravenous injection with 2–4 mg atropine sulfate and 1,000–2,000 mg pralidoxime chloride or 250 mg toxogonin (adult dose). Exposure to high levels of malathion that result in respiratory distress, convulsions, and unconsciousness should be treated with atropine and a re-activator. Morphine, barbiturates, phenothiazine, tranquillizers, and central stimulants are all contraindicated.</td>
</tr>
<tr>
<td>Fenitrothion</td>
<td>Fenitrothion is the most toxic to man of the insecticides approved for residual house spraying, and has a relatively low margin of safety. Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor.</td>
<td>Dermal exposure to fenitrothion should be treated by removing contaminated clothing, rinsing the skin with water, washing the exposed areas with soap and water, then seeking medical attention. If fenitrothion gets into the eyes, they should be rinsed with water for several minutes. Contact lenses should be removed if possible and medical attention should be sought. Ingestion of fenitrothion should be treated by rinsing the mouth and inducing vomiting if the person is conscious. Inhalation exposures require removal to fresh air and rest in a half-upright position. Artificial respiration should be administered if indicated and medical attention should be sought.</td>
</tr>
<tr>
<td>Organophosphates</td>
<td>Human side effects</td>
<td>Treatment</td>
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<tr>
<td>Pirimiphos-methyl</td>
<td>Pirimiphos-methyl is also a cholinesterase inhibitor. Early symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, stomach pains, blurred vision, constricted pupils, slurred speech, and muscle twitching. Later there may be convulsions, coma, loss of reflexes, and loss of sphincter control.</td>
<td>OP poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spraymen (in the case of dispersed operations) should be trained in first-aid and emergency treatment of OP intoxication. The affected person should stop work immediately, remove any contaminated clothing, wash the affected skin with soap and clean water and flush the skin with large quantities of clean water. Care must be taken not to contaminate others, including medical or paramedical workers. Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic OP insecticides are used in areas without easy access to medical care. Atropine sulfate. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible. Glycopyrolate has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.</td>
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<tr>
<td>Pyrethroids</td>
<td>Human side effects</td>
<td>Treatment</td>
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<td>Bifenthrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness. No skin inflammation or irritation observed; however, can cause a reversible tingling sensation. Incoordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses.</td>
<td>Depends on the symptoms of the exposed person. Casual exposures require decontamination and supportive care. Wash affected skin areas promptly with soap and warm water. Medical attention should be sought if irritation or paresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline.</td>
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<tr>
<td>Deltamethrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
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<tr>
<td>Lambda-Cyhalothrin</td>
<td>Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning. Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions. Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis.</td>
<td>Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.</td>
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<tr>
<td>Pyrethroids</td>
<td>Human side effects</td>
<td>Treatment</td>
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<tr>
<td>Alpha-cypermethrin</td>
<td>Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia.</td>
<td>Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.</td>
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<td></td>
<td>Acute inhalation exposures may cause upper and lower Respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful</td>
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<td>Cyfluthrin</td>
<td>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
</tr>
<tr>
<td>Etofenprox</td>
<td>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
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**Summary of Acute Exposure Symptoms and Treatment of Chlorfenapyr**

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<tr>
<th>Pyrrole</th>
<th>Human side effects</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>Chlorfenapyr</td>
<td>As chlorfenapyr is a rather new product there are not many cases of poisonings where the symptoms were described. One incident involved someone who experienced an asthma attack after a nearby office was sprayed. The only symptoms reported were respiratory effects. This case was ranked as low severity. Another exhibited general fatigue, hyper-perspiration, nausea and vomiting. He was initially diagnosed as being dehydrated. And a third was hospitalized due to exogenous intoxication with chlorfenapyr with suicidal purposes, initially presenting diaphoresis, headache and cough. Symptomatic management was initiated, but after seven days she presented neurological and respiratory deterioration, causing her death.</td>
<td>As chlorfenapyr affects the central nervous system, it can be managed through supportive care and early treatment of seizure through benzodiazepine. No specific symptoms can be said for exposure by inhalation or ingestion. Possible generalized symptoms include nausea and vomiting. Prolonged contact of the skin with the concentrate may cause irritation. Eye contact may cause some discomfort if contact is prolonged. Evidence from prolonged animal studies indicates that repeated or prolonged exposure to high doses of chlorfenapyr can result in spongiform (encephalomyelopathy) and effects on the liver and kidney.</td>
</tr>
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</table>
ANNEX E: REFERENCES


Basal Convention. Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT)

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