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SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR NATIONWIDE IRS IN MADAGASCAR (2019-2023)

Recommended Citation: Supplemental Environmental Assessment for Nationwide IRS in Madagascar (2019–2023), Abt Associates, Inc., Rockville, MD 20852

Contract: AID-OAA-I-17-00008

Task Order: AID-OAA-TO-17-00027

Submitted to: United States Agency for International Development/PMI

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SEA FOR NATIONWIDE IRS IN MADAGASCAR USING CARBAMATE, ORGANOPHOSPHATE, PYRETHROID, CLOTHIANIDIN, CLOTHIANIDIN/DELTAMETHRIN COMBINATION AND CHLORFENAPYR (WHEN WHO-PQ LISTED)

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ACRONYMS

AIRS	Africa Indoor Residual Spraying Project
BMP	Best Management Practices
CDC	Centers for Disease Control and Prevention (U.S.)
CFR	Code of Federal Regulations (U.S.)
COR	Contracting Officer's Representative
EMMP	Environmental Mitigation and Monitoring Plan
HLC	Human landing catch
IEC	Information, Education, and Communication
IRS	Indoor Residual Spraying
ITN	Insecticide-treated Net
IVM	Integrated Vector Management
MIS	Malaria Indicator Surveys
MOH	Ministry of Health
MSP	Mobile Soak Pit
NFM	New Funding Model
NMCP	National Malaria Control Program
NSP	National strategic Plan for Malaria
PEA	Programmatic Environmental Assessment
PMI	**U.S.** President's Malaria Initiative
PPE	Personal Protective Equipment
RBM	Roll Back Malaria
RDT	Rapid diagnostic test
SBCC	Social and behavior change communication
SEA	Supplemental Environmental Assessment
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WHO PQ	World Health Organization Prequalification

EXECUTIVE SUMMARY

This document has been prepared to serve as a Supplemental Environmental Assessment (SEA) for Indoor Residual Spraying (IRS) in Madagascar supported by the U.S. President's Malaria Initiative (PMI) for the period 2019 – 2023. This update was prepared in accordance with the provisions of Title 22 of the United States Code of Federal Regulations, Part 216 (22 CFR 216) regarding the use and application of pesticides. As required by the 22 CFR 216, only World Health Organization (WHO) Pre-Qualification (PQ)-listed pesticides are acceptable for IRS operations supported by PMI. Previous United Stated Agency for International Development (USAID) environmental documentation for IRS in Madagascar authorized the use of WHO-recommended pesticides in the pyrethroid, carbamate, organophosphate and neonicotinoid classes nationwide from 2013 to 2018. In addition, an SEA Amendment was written and approved in July 2018 that authorized the use of clothianidin and a clothianidin/deltamethrin mixture. This SEA proposes to reauthorize the use of the same six classes of insecticides, including the use of chlorfenapyr in the pyrrole class, when listed by WHO PQ. Additionally, the SEA seeks nationwide coverage of authorized PMI-supported IRS, and requests authorization of small-scale, closely supervised hut trials using new IRS insecticides, when the insecticide has been submitted for Phase III PQ evaluation, and Madagascar-level required documentation has been submitted and approved.

In 2019 funding, PMI will continue to support IRS in up to five high-burden districts. While the estimated number of structures will remain consistent (approximately 350,000 structures), the selection of the targeted districts may change, prioritizing the highest burden areas. In 2019, Madagascar will conduct IRS with Actellic, Sumishield and Fludora Fusion. In the future, results of resistance testing, insecticidal activity duration testing, and the availability of new pre-qualified listed insecticides will be considered when selecting insecticides.

In Madagascar the result of susceptibility tests of the vector indicated full susceptibility of *An. gambiae* s.l. to pirimiphos-methyl in all areas where the tests were conducted. The test results also showed that *Anopheles gambiae* s.l. had developed resistance to permethrin in Lanivo/Anosy, Vavatenina and Vohitrambato; to deltamethrin in Ambodifaho, Vohitrambato, Vavatenina and Ambohimiarina II; and to alpha-cypermethrin in Vavatenina. Suspected resistance was noted for DDT in Vavatenina; for permethrin in Ambodifaho; for deltamethrin in Marofarihy (Manakara); for lambda-cyhalothrin in Vohitrambato and for bendiocarb in Vavatenina[1].

The 2018 amendment to include new insecticides was prompted by the need to increase the available options for IRS. Clothianidin, SumiShield, a neonicotinoid, was listed by the WHO PQ in 2017, and a combination clothianidin/deltamethrin product, Fludora Fusion which was listed in 2018. Chlorfenapyr, a member of the pyrrole chemical class, if listed by WHO PQ and authorized by the Ministère de l'Environnement et du Développement Durable for use in Madagascar, will offer additional options for insecticide rotation.

This SEA for IRS in Madagascar outlines the monitoring and mitigation measures that the PMI Implementing Partner (IP) will use to minimize or reduce any adverse impacts of pesticide application. Those measures are found in the Safer Use Action Plan (Section 7), and summarized in the Environmental Mitigation and Monitoring Plan (EMMP), found in Annex A. All PMI IRS operations in Madagascar will be performed according to the protocols and procedures found therein. These procedures do not change with the use of different classes of authorized pesticides, with the following exceptions:

1. Because of the potential cumulative effects of organophosphate exposure (e.g., cholinesterase depression), team leaders and senior staff will need increased emphasis and training on their

[1] 2018 PMI VectorLink Madagascar Entomology Progress Report

responsibility and ability to constantly monitor the appearance and behavior of their team members and to recognize the symptoms of organophosphate exposure in order to implement response protocols. Biomonitoring is not required for the use of pirimiphos-methyl formulations for IRS at the present time, but increased vigilance is essential.

2. Pirimiphos-methyl formulations are supplied in plastic bottles, which if not controlled carefully may be used inappropriately once emptied of the insecticide. In addition, incineration of the bottles may cause harmful emissions. Because of these potential problems, the following procedures and protocols have been established:

    a. A triple rinse for the plastic bottles has been incorporated during the insecticide mixing procedure, whereby the insecticide container is emptied into the spray tank and then three times the bottle is partly filled with clean water, capped, shaken, and emptied into the spray tank. This ensures that the insecticide is used more efficiently, and that the container is thoroughly rinsed of pesticide and therefore safe for handling and subsequent use. The risk of exposure due to insecticide residue in the container is essentially eliminated; however, the following procedures are also followed:

        i. Containers are punctured multiple times so no one can reuse them.

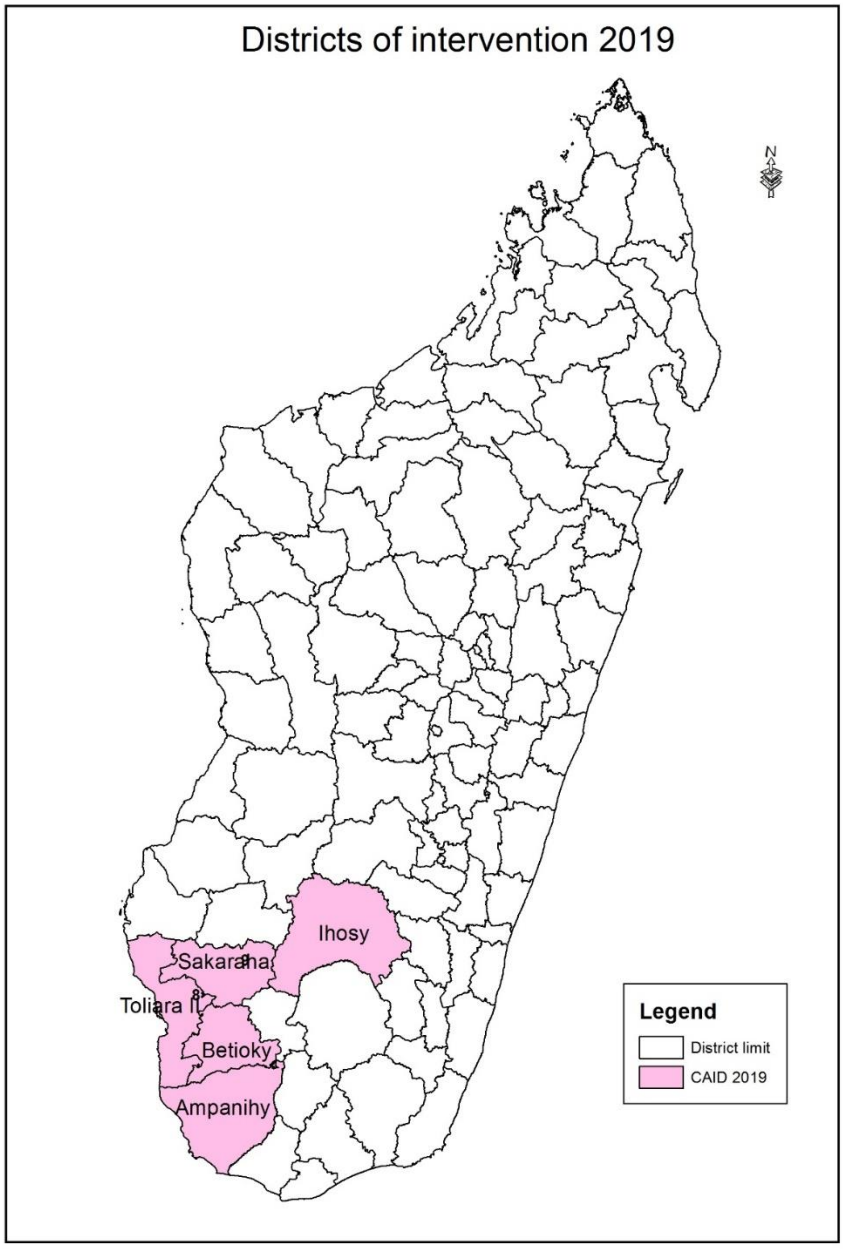
        ii. Recycling programs have been established to turn the plastic into usable non-food products. Through close supervision and chain of custody, and in partnership with the Office National de l'Environnement (ONE), and the Madagascar NMCP, the implementing partner will ensure that the plastic remains segregated from other supplies, is used for items such as oil tanks, patio flagstones or electrical conduit, and will not be used for products that contain consumables. The recycling programs have prevented the emission of many tons of carbon dioxide and other potentially toxic chemicals from the incineration of plastic.

The PMI IP will implement the EMMP in Annex A, with guidance from PMI and the NMCP and with the assistance and involvement of the local communities. All senior staff in charge of IRS implementation will be trained to monitor operations when in the field, in order to maximize supervisory oversight and ensure the effectiveness of the mitigation measures during spray operation. The district coordinators will also monitor environmental compliance during the IRS campaign. The IP will complete the annual Environmental Mitigation and Monitoring Report Form in Annex B and submit it to PMI along with the annual End of Spray Report.

This SEA obviates the need for a letter report in 2019, but normally a letter report will be submitted annually to the Contracting Officer's Representative (COR) and Bureau Environmental Officer (BEO) prior to the spraying campaign. It will contain information regarding program changes, entomological resistance monitoring results, and program response to those results. It will also state how the program will improve on any areas of deficiency.

The following assessment draws heavily on the Programmatic Environmental Assessment (PEA) for Integrated Vector Management (IVM), updated in 2017, and many other reference documents, as noted throughout this document.

Figure 1: Districts of Intervention



I. Principal Proposals and Clearance

1. The Madagascar Supplemental Environmental Assessment (SEA) (2013), as amended in 2018 (amendment #1), was valid for implementing USAID-supported IRS in all areas of Madagascar for the period 2013 – 2018.
2. In order to continue with PMI IRS, PMI is seeking approval for a new SEA effective for five years (2019–2023), and for the SEA to be nationwide in scope.
3. This SEA will authorize the continued use of all WHO-recommended pesticides in the pyrethroid, carbamate, organophosphate and neonicotinoid classes, and also authorizes the use of chlorfenapyr when recommended by WHO PQ.
4. In order to increase its current inventory of protected environments and habitats, the Government of Madagascar (GoM) has been expanding its protected area network to meet the 10% of the country's land surface to meet the International Union for the Conservation of Nature standard for protected area coverage. Some of the new protected areas include villages, communes and fokantany that have been or are now targeted for IRS. In general, and nearly exclusively, these communities are in buffer zones of the protected areas, and IRS is permitted in the buffer zones. However this SEA contains the condition that spraying will not be performed by PMI IPs within 30 meters of natural water bodies, wetlands or marshes, organic farming areas, beekeeping areas, or the core areas within protected forests, parks or habitats.
5. It is further proposed to allow for small studies or hut trials to evaluate new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III PQ evaluation, and once the required Madagascar-level documentation has been submitted and/or registration is completed.
6. The Safer Use Action Plan in Section 6 provides detailed guidance on the performance of all activities associated with IRS. The attached, updated Environmental Mitigation and Monitoring Plan (Annex A) summarizes the key required mitigation measures, as well as the monitoring and reporting requirements and schedule.
7. The preparation of this SEA renders a Letter Report unnecessary for 2019. In subsequent years, provided there are no changes to the program outside the scope of this SEA, a Letter Report will be submitted to PMI annually that will discuss significant changes in the IRS program for that particular year's spray campaign.
8. This SEA contains an updated Pesticides Procedures section, which together with the Safer Use Action Plan constitute the elements of a Pesticide Evaluation Report and Safer Use Action Plan.

APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED

2019–2023 SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT'S MALARIA INITIATIVE- INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN MADAGASCAR

The USAID Global Health Bureau has determined that the proposed IRS effort, as described in this SEA, responds to the needs of the community and Madagascar with respect to managing malaria in Madagascar and also conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS. Rather, it 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 were established to avoid and reduce any potential adverse impact. USAID has concluded that the proposed action, when executed as described in the SEA and the PEA for PMI IVM (2017), is consistent with the Government of Madagascar's and PMI's goal of reducing malaria incidence in Madagascar while minimizing negative impact to the environment and to human health.

The proposed actions recommended for approval in this 2019 SEA are:

1. Continue IRS implementation using pyrethroids, carbamates, organophosphates, neonicotinoids and the clothianidin/deltamethrin combination, and/or chlorfenapyr (when PQ-listed), where appropriate, based on criteria such as transmission rate, vector susceptibility, residual effect, appropriate home and wall structure, economic factors, and ecological/human health impacts.
2. This SEA will continue coverage of all geographical areas in Madagascar where IRS may be implemented or where PMI may provide national- or regional-level support as decided by the NMCP and PMI for the five-year period from 2019 to 2023.
3. This SEA authorizes small, closely supervised studies or hut trials to study new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHO PQ evaluation and Madagascar-level required documentation has been submitted.
4. Given the successful record of PMI in implementing IRS in Africa without significant environmental consequences, it is proposed to continue to allow IRS in the buffer zones of environmentally protected areas, using the strict protocols and procedures contained in the PMI best management practices (BMP) manual, and observing all precautions and prescriptions in this SEA. This IRS is intended to protect people in these buffer zones from malaria.

The Safer Use Action Plan (Section 6) and the updated Environmental Mitigation and Monitoring Plan for Madagascar (Annex A) provide detailed guidance on the performance of all activities associated with IRS. Through the use of this and other guidance, PMI has maintained an excellent record of success in executing IRS without substantial environmental or human health impact.

CLEARANCE:

USAID/Madagascar Mission Director: _____ Date: 9/20/19

CONCURRENCE:

GH/ Bureau Environmental Officer : Dennis W Durbin (affiliate) Digitally signed by Dennis W Durbin (affiliate) Date: 2019.10.03 10:47:56 -04'00' Date: _____

Dennis W Durbin

ADDITIONAL CLEARANCES:

AFR/Bureau Environmental Officer : _____ Date: 10/10/19

PMI/Madagascar Resident Advisor: _____ Date: 09/16/19

USAID/Madagascar Mission Environmental Officer: _____ Date: 9/11/19

Salohy Soloarivelo

USAID/Madagascar Climate Integration Lead: _____ Date: 9/11/2019

Serge Ramanantsoa

USAID/Regional Environmental Advisor: _____ Date: 9/11/19

2. BACKGROUND AND PURPOSE

2.1. PRESIDENT'S MALARIA INITIATIVE

Launched in 2005, the goal of the U.S. President's Malaria Initiative (PMI) is to reduce malaria-related deaths by 50 percent in 19 countries in Africa that have a high burden of malaria by expanding coverage of four highly effective malaria prevention and treatment measures to the most vulnerable populations: pregnant women and children under five years of age (USAID 2005). These interventions include ITNs, indoor residual spraying (IRS) with insecticides, intermittent preventive treatment for pregnant women (IPTp), and prompt diagnosis and treatment with use of artemisinin-based combination therapies (ACTs)

In 2017 the United States Agency for International Development (USAID) awarded Abt Associates a five-year PMI funded contract to contribute to the prevention of mosquito-borne diseases. This new VectorLink project will continue to work closely with Ministries of Health (MOH), National Malaria Control Programs (NMCP), district health offices, local non-governmental organizations, and community leaders to ensure that government, the private sector, and communities are able to sustain and lead future IRS and malaria control programs in their respective countries. Through this Task Order contract, Abt will support PMI and USAID to plan and implement an integrated vector control approach with the overall goal of reducing the burden of malaria. Abt has implemented indoor residual spraying (IRS) and performed entomological monitoring under PMI funding since 2011, delivering high-quality IRS programs and gathering the most comprehensive vector control entomological data in the world.

2.2. PROGRAM OBJECTIVES

Madagascar recently developed the National Strategic Plan (NSP) 2018-2022, which the MOH adopted in November 2017 based on recommendations from a 2016 malaria program review and input from all malaria stakeholders. The NSP focuses on improving malaria control in higher-burden zones and initiating malaria elimination efforts in very low-burden zones of the country. Zone classification was based on epidemiologic stratification estimated from the 2016 Malaria Indicator Survey (MIS), malaria surveillance data, and a vulnerability index calculated from healthcare utilization and poverty data (see Table 1). Of the 114 districts in the country, 106 are classified as control, 3 as pre-elimination, and 5 as elimination.

The project's goal for 2019 is to meet PMI's objective of covering at least 85 percent of eligible structures found in all communes/districts targeted for spraying.

The main objectives of the project for the 2019 IRS campaign are as follows:

1. Strengthen the capacity of seasonal spray campaign supervisors and government officials in monitoring/supervision of IRS activities
2. Strengthen the National Malaria Control Program's (NMCP) capacity in entomological and environmental compliance monitoring
3. Ensure that teams carry out high quality spraying on time, before the peak transmission season
4. Collect, analyze and disseminate routine epidemiological and entomological data in the high burden malaria areas, in partnership with the NMCP.

PMI/Madagascar recommended that two (2) districts in the South West (Sakaraha and Tulear II) targeted in 2018, with three (3) new districts (Ampanihy and Betioky sud) in the South West and Ihosy in Ihorombe's region will be targeted for the 2019 spray campaign using Actellic® 300 CS and SumiShield® 50 and Fludora Fusion. The 2019 IRS campaigns are scheduled for 24 operational days beginning November 4th and ending around November 30th , 2019 in all 5 districts

2.3. History and Scope of Malaria Control Efforts in Madagascar

PMI has implemented IRS programming in Madagascar since 2008, with PMI's current support for IRS programming in Madagascar falling within the objectives and parameters of the 2018-2022 National Malaria Strategy.

Through 2011, all IRS programming was categorized as "generalized" or blanket spraying, providing IRS to as close to 100% of the eligible structures in targeted districts as possible. This IRS strategy has been largely successful through the strong collaboration between PMI, NMCP and the Global Fund.

2.4. New Or Expanded Activities And Key Changes

2.4.1. Vector control

2.4.1.1. Entomologic monitoring and insecticide resistance management

PMI will continue to support approximately 11 entomological sentinel sites collecting routine entomological indicators and conducting insecticide resistance monitoring. While the number of sites will remain the same, the location of one to two entomological sites will shift from high-burden areas to the elimination district(s) where PMI will be supporting the NMCP with elimination activities. The 2018 results of PMI-supported entomological monitoring in Madagascar can be found here: https://www.pmi.gov/how-we-work/technical-areas/entomological-monitoring

2.4.1.2. Insecticide-treated nets

The NMCP adopted the goal of universal ITN coverage in 106 of 114 health districts (i.e., one ITN for every two people in malaria-control districts). To achieve this goal, which expands universal coverage from 92 to 106 districts, the NMCP plans mass distribution campaigns every three years to provide free ITNs in these districts. In addition, PMI and Global Fund support continuous distribution of ITNs at the community level in up to 20 high-transmission districts, and routine ITN distribution (i.e., during immunization and antenatal care (ANC) visits at health centers).

PMI supports the 2018-2022 NSP goal of universal coverage with one ITN per two people in 106 of Madagascar's 114 health districts; the most recent 2018 campaign distributed 13 million ITNs in collaboration with the Global Fund.

Mass distribution campaign

The latest mass distribution campaign was done in the country in 2018 with the coverage of a total of 106 districts through both funding of PMI and GFATM/ NMF. The next mass distribution campaign is scheduled for 2021. PMI and GFATM are still supporting the country for the purchasing and distribution of the LLINs.

Routine distribution

Routine and continuous distributions have always been undertaken in Madagascar with the support of PMI and GFATM. The routine distribution circuit provides mosquito nets for pregnant women attending antenatal consultation care and the expanded immunization program for children aged 0-11 month completely vaccinated (PEV) and the children under 5 years old attending the external consultation. Since 2017, different districts have been particularly targeted for continuous distribution or regular distribution has taken place in all districts

2.4.2. Indoor Residual Spraying

IRS remains a key intervention for malaria control in select districts; PMI is the main donor supporting this activity. PMI continued blanket IRS in high-transmission districts of the east and south east in 2018, in addition to adding two districts in the south west. An insecticide rotation plan with new long-lasting insecticides has begun in 2018 to mitigate resistance.

In Madagascar indoor residual spraying started with the world wide malaria eradication program of WHO since 1949. It was stopped in the 1970s and resumed since 1988. From 2017 to date, the country has sprayed approximately 67 (with the riposte) districts throughout the country with the support of PMI and GFATM/NMF.

Table 1: History of PMI-Supported IRS in Madagascar

Year	Geographic Area	IRS Strategy	Insecticide
2012	AIRS Madagascar completed focalized IRS in 41 communes in the CHL, spread across seven districts, and in Tolagnaro (Fort Dauphin) district, covering five communes. AIRS Madagascar continued blanket spraying in 95 communes spread across seven districts in Southern Madagascar.	Focal & Blanket	
November-December 2013	CHL and Fringe (~40 *communes*)	Focal	Pyrethroid and Carbamate
2013	Madagascar's Central Highlands (CHL) received focalized IRS, and three districts in the East Coast (Fenerive Est, Brickaville and Tamatave II) received blanket spraying	Focal & Blanket	
September November 2014	East Coast (3 districts)	Blanket	Organophosphate
August-October 2015	East Coast (3 districts) and South East (1district)	Blanket	Organophosphate
August-October 2016	East Coast (3 districts) and South East (2 districts)	Blanket	Organophosphate
August- September 2017	East Coast (3 districts) and South East (5 districts)	Blanket	Organophosphate
August-September 2018	East Coast (3 districts) South East (4 districts) South West (2 districts)	Blanket	Organophosphate Neonicotinoid (SumiShield)
November 2019	Tulear II, Sakaraha, Betioky, Ampanihy, Ihosy	Blanket in the selected districts	Organophosphate & Neonicotinoid (SumiShield & Fludora Fusion)

2.4.3. OTHER KEY PREVENTION INTERVENTIONS

Malaria in pregnancy: While Madagascar's multi-pronged approach to MIP remains the same, the number of districts implementing IPTp has increased from 93 to 106 as a result of the revised malaria stratification in the current NSP. The NMCP aims to achieve coverage of 76 percent of pregnant women with three doses of IPTp in 106 districts by 2022. Additionally, the MOH has updated its national ANC norms and guidelines to reflect the 2016 WHO ANC recommendations, which include promoting eight ANC contacts during pregnancy. The guidelines also recommend an additional ANC visit between 13-16 weeks to ensure the first dose of IPTp is

provided as early as possible in the second trimester. The updated ANC guidelines were finalized and disseminated to health staff in May 2018

IPTp: The NMCP adopted the 2016 WHO IPTp recommendations and trained health facility staff on these. Under the new NSP and re-stratification, IPTp will be administered in 106 districts targeted for malaria control, an increase from 93 districts previously targeted.

Case Management: The NMCP plans to extend community-based case management of malaria, currently targeting children under 5 years of age, to children aged 6-15 years as a pilot activity in high-burden, hard-to-reach districts. Recent epidemiologic data indicates that these children are among the most affected by malaria. The NMCP also plans to scale up pre-referral treatment with rectal artesunate of severe malaria cases in children under six years of age across the country. In pre-elimination districts, low-dose primaquine will be used to reduce transmission, and outbreak response according to MOH policy may include mass drug administration and active case detection. The malaria case management strategy remains largely unchanged from 2017 with a few exceptions.

More details can be found in Madagascar Malaria Operational Plans here: https://www.pmi.gov/where-we-work/madagascar

3. PROPOSED Action and Alternatives

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:

3.1. DESCRIPTION OF PROPOSED ACTION

The preferred action is to implement an IRS program in selected communities, choosing among the pyrethroid, carbamate, organophosphate, neonicotinoid classes and the clothianidin/deltamethrin combination, as well as chlorfenapyr when PQ-listed, considering current entomological, epidemiological, logistical, and environmental conditions. Insecticides to be used in 2019 were determined by a process explained in Pesticide Procedures (Section 6), and include pirimiphos-methyl marketed as Actellic 300CS, clothianidin marketed as SumiShield 50WG and a combination clothianidin/deltamethrin product, Fludora Fusion. All used insecticides are managed in accordance with both host country regulations and US 22 CFR 216.

3.2. NO-PROJECT ALTERNATIVE

IRS 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 goals of Madagascar's NMCP National Strategical Plan 2018 – 2022, the Global Fund's Technical Strategy, or PMI's Strategy for 2015–2020.

3.3. ALTERNATIVE IRS GEOGRAPHICAL SITES CONSIDERED

In IRS implementation, areas considered highly malarious and those areas that fit within the NMCP strategic plan were considered, while lower-risk areas were not considered for IRS as an intervention. Using different criteria for selecting geographical sites would reduce the effectiveness and impact of IRS, decreasing progress towards the goals of the Madagascar NMCP and the PMI program.

3.4. USE OF ALTERNATIVE INSECTICIDE(S)

For IRS to be implemented, a pesticide listed by the WHO PQ, must be selected for use. The PQ is an international institution that analyzes and recommends pesticides to be used in IRS based on their effectiveness, and toxicity to human health and the environment.

To date, the WHO PQ has recommended the use of pesticides within the following six classes of pesticides: pyrethroids, carbamates, organochlorines, organophosphates, neonicotinoids and clothianidin/deltamethrin combination. The proposed action for Madagascar includes the use for IRS of these approved formulations including chlorfenapyr when recommended by the WHO PQ, but with the exception of organochlorines (DDT).

PMI and their IPs will monitor WHO PQ proceedings towards recommendation of new pesticides, but will seek to amend this SEA before there is any decision to use new WHO PQ recommendations, other than chlorfenapyr.

3.5. ALTERNATIVE TECHNOLOGIES

A full range of known, available technologies are 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 other technologies.[2] The specific focus of this PMI project is IRS and ITNs, and the role that PMI plays in Madagascar includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays, the NMCP, PMI, and its partners would evaluate them and proceed accordingly.

[2] PRESIDENT'S MALARIA INITIATIVE Madagascar Abbreviated Malaria Operational Plan (MOP) FY 2019

4. AFFECTED ENVIRONMENT

This section describes the environments and ecosystems that could be adversely affected in the implementation of the IRS program if adequate and necessary mitigation measures and monitoring are not put into place. These critical ecosystems or activities include surface water bodies (lakes, river, groundwater, marshlands and wetlands), air, soils, and economic and sustenance activities including agriculture, apiculture, fisheries and organic farming that might be adversely affected by application of pesticides.

4.1. OVERVIEW OF MADAGASCAR

Madagascar is the world's fourth largest island that is 1,600 km long, up to 500 km wide, and has a surface area of 587,041 km², making it a little larger than France. Its coastline of 5,000 km is fringed with some 260 small islands. Now laying an average of 500 km from the East African coast, Madagascar originally formed part of the Gondwana super-continent. The joint land mass made up of Madagascar and India then broke off from the African mainland around 180 million years ago during the late Middle Jurassic period. Madagascar split from India around 80 million years ago in the Late Cretaceous period and has since occupied its present solitary position in the Western Indian Ocean.

Due to its isolation, Madagascar has developed a unique fauna and flora derived from forms present on the island at its separation and from numerous subsequent accidental colonists. It is best known for the lemurs, primitive primates related to the bush babies of Africa that have diversified into numerous forms (more than 32 taxa), some already extinct. Similar patterns of radiation are known for the birds (vangas), and for many other plant and animal groups. The level of endemism of the native flora and fauna is high — an average of about 80 percent for all taxa at the species level, with many genera and even families unique to the island. Referred to a "laboratory of evolution," Madagascar is one of the world's mega-diversity countries and Africa's highest conservation priority. However, IRS activities will not affect these unique biodiversity and ecological zones that are under legal protection status by the government of Madagascar. VectorLink maps target settlements during the reconnaissance and logistics assessment studies and excludes structures in sensitive habitats.

4.1.1. ADMINISTRATIVE AND POLITICAL UNITS

Madagascar is currently divided into 22 regions created in 2004. These formerly second-tier administrative divisions became the first-level administrative divisions when the former six provinces were dissolved on 4 October 2009. But in the new constitution, adopted in 2010, six autonomous provinces were listed again. The regions are further subdivided into 114 districts, 1,548 communes, and 16,969 fokontany. The major cities have a special status as "*commune urbaine*", at the same level as the districts.

Districts are in their turn divided into communes; while some of the districts in urban areas (such as the City districts of Antananarivo, Antsirabe I, Antsiranana I, Fianarantsoa I, Toamasina I and Toliara I) and offshore islands (such as the districts of Nosy Be and Nosy Boraha) each consist of only one commune, most of the districts are divided typically into 5–20 communes.

Table 2: Provinces and Regions in Madagascar

Provinces	Regions
Antananarivo (1)	Analamanga, Bongolava, Itasy, Vakinankaratra
Antsiranana (2)	Diana, Sava
Fianarantsoa (3)	Amoron'i Mania, Atsimo-Atsinanana
	Haute-Matsiatra, Ihorombe, Vatovavy-Fitovinany
Mahajanga (4)	Betsiboka, Boeny, Melaky, Sofia
Toamasina (5)	Alaotra Mangoro, Analanjirofo, Atsinanana
Toliara (6)	Androy, Anosy, Atsimo-Andrefana, Menabe

4.1.2. POPULATION

According to the World Population Review, Madagascar's population is 26,770,646 (2019 est.), and WHO has determined it has been growing at an average rate of 2.9 percent per year since 1990. The population of Madagascar is mainly concentrated in the central highlands (about 75 percent) with the highest densities occurring south of Fianarantsoa along the east facing slopes. In the west, populations are sparse except in the big coastal towns, which now account for about 10 percent of the total population.

4.2. PHYSICAL ENVIRONMENT

4.2.1. CLIMATE

Madagascar lies in the tropical and subtropical marine region of the Western Indian Ocean. Spanning almost 14° of latitude, mean open water surface water temperatures range between 22° and 28° C, with minimum temperatures in August and maximum temperatures in February (Cooke et al., 2000). The extreme south of Madagascar is affected by nutrient rich, cold waters rising from the south. Madagascar's marine and coastal environments may be split into two basic zones — east and west.

HISTORICAL CLIMATE

Climate changes since the 1950s include:

- Significant increases in daily temperatures across all seasons, and pronounced increases in daily maximum temperatures during the dry season.
- Increased variability in the relative distribution of temperature and rainfall, with higher temperatures and decreased rainfall in the northern areas and increased rainfall in the southern areas.
- Reduction in the length of the dry season and longer periods of drought in the central and western parts of the country.
- Increased intensity of rainfall during cyclones.
- More frequent extreme events, with increased intensity.

FUTURE CLIMATE projected changes include:

- Average temperature will increase 2.5° – 3°C by 2100.
- Rainfall will reduce overall, particularly during the dry season and in inland areas, and increased amounts of rain will fall during the rainy season (December – February) by 2065.
- Projected changes in rainfall are less certain for the north, with some models suggesting drier conditions and others suggesting wetter conditions.

By 2100, the frequency of cyclones is projected to decrease over the Indian Ocean, particularly at the beginning of the cyclone season. However, cyclone intensity is projected to increase by almost 50 percent, with landfall tracks shifting northward.[3][4] Please see the project-wide Climate Risk Management Plan for more detail on climate change risks and adaptation.

4.2.2. RAINFALL PATTERNS

The east coast is wet for much of the year as it is exposed to the trade winds, which are forced to rise as they meet the steep eastward-facing escarpment. Most of the east coast receives over 2,000 mm/80 in annual rainfall as does another small area in the northwest around Diego Suarez. Rainfall is lower on the interior plateau and decreases to the west and south. The lowlands in the southwest of the island only receive between 400-800 mm/16 -32 in of rain a year, mostly falling between December and March. The central plateau areas receive an annual rainfall intermediate between these extremes, varying between 1,000 mm/40 in and 1,500 mm/60 in. Most rain here falls between November and March, much of it in heavy downpours associated with hail and thunder. The rainfall during the rest of the year is mostly very light and sporadic. On the plateau temperatures fall to moderate levels during the dry season and the nights may be chilly, but frost only occurs on the highest mountains

4.2.3. TOPOGRAPHY, GEOLOGY[5], AND SOILS

Madagascar is made up of an ancient Pre-Cambrian crystalline basement in the form of a lozenge aligned southwest-northeast, which has been tilted to create an escarpment along its eastern edge, and overlaid in the west by millions of years of accumulated sediments forming a western sedimentary plain. The continental shelf is mostly narrow and steep in the east with a shallow shelf sloping in the west. The eastern side is bathed in moist trade winds, while the west is mainly dry and the southwest arid, all of which create a large range of climatic conditions and diversity of habitats. Ferruginous and ferralitic soils represent almost 70 percent of the total national area. A further 27 percent of the national territory is characterized by mineral soils in the highlands, western watershed and the far south. The remainder comprises calcimorphic, halomorphic (saline) and hydromorphic (peats) soils.

4.3. ECO-REGIONS

4.3.1. FRESH WATER ECOSYSTEMS AND WETLANDS

There appear to have been only limited attempts to classify Malagasy wetlands into distinct eco-regions (see summary in IUCN/UNEP/WWF, 1987). Starmuhlner (1979) separates freshwater mollusk distribution into three bioclimatic regions:

- The steppe-like Central High Plateau
- The eastern slopes of the High Central Plateau
- Southeastern and western areas where surface waters are richer in salts.

Malagasy wetlands are divided into five categories, some of which are subdivided further on the basis of geographical distribution. Madagascar straddles two major climatic systems. Eastern Madagascar lies in the tropical rainforest belt while southwestern Madagascar lies in the belt of dry climate that runs across the southern Indian Ocean from Australia to Southern Africa. Thus, within one country annual rainfall varies from

[3] Ministère de l'Environnement, des Eaux, et des Forêts. 2006. Programme d'action national d'adaptation au changement climatique.

[4] World Bank (GFDDR). 2011. Climate Risk and Adaptation Country Profile: Madagascar.

[5] Thomas Schlüter, Geological Atlas of Africa With Notes on Stratigraphy, Tectonics, Economic Geology, Geohazards and Geosites of Each Country

more than 4,000 mm in the northeast (Masoala, Mananara) to less than 100 mm in the southwest. This large range in rainfall together with variations in physical relief and geology, generate a diversity of freshwater and wetland ecosystems.

Madagascar's freshwater and wetland ecosystems are of exceptional importance for biodiversity in view of the high numbers of aquatic species and high levels of endemism, particularly in relation to fishes, other freshwater aquatic fauna and the dependence on wetlands of certain endemic birds and global populations of migratory birds.

The indigenous Madagascar fish fauna is as species-rich as would be expected from the island's size, with 141 species and 91 endemic species, many of which have highly localized distributions (Stiassny & Sparks in press). Certain elements of the freshwater fauna show altitudinal variation (e.g., the Philopotamid insects). Thus, species at lower altitudes are especially threatened since the effects of disturbance to water courses are cumulative. The aquatic insect fauna of the eastern escarpment shows a high degree of micro-endemism, i.e., species have very small ranges. In the west, species are fewer in number but more widespread; some are restricted to the middle reaches of rivers where hydrological conditions are more constant (Gibon, 2000).

4.3.2. RIVERS

Rivers flowing eastward from the Central High Plateau are relatively short. Flow speed and turbidity on the Plateau are variable depending on relief and land use patterns. Eastern rivers are fast flowing on the upper slopes of the Plateau, and traverse a variety of substrates including rocks, gravel, sands and laterite. Where vegetation cover is dense, the rivers are generally clear.

Many western flowing rivers are long, with the longest including the Betsiboka, Loza, Mahavavy, Manambolo, Tsiribihina, Mangoky and Onilahy. Their habits on the High Central Plateau resemble those of the eastern flowing rivers. Some carry significant sediment load by the time they traverse the western reaches of the Central High Plateau but extensive sand deposition is a characteristic feature of rivers flowing across the lower peneplains and coastal plains. Dense stands of Phragmites grasses and *Pandanus* are common along many of the banks. Smaller rivers (but some more than 100 km long) stop flowing during the dry season, especially in the south.

The Pangalana: This waterway parallel to much of the east coast has generally clear; acidic waters with low sedimentation. In places, some native forest cover remains but most surrounding areas have been cleared. Floating vegetation is rare, and the banks are often lined by sedges, Raffia palms, *Pandanus* and tall taro-like plants (Typhonodorum) endemic to the county.

Marshes: Marshland in the Eastern moist forests occurs along rivers where flow is restricted by natural bottlenecks. Most are relatively small but larger sites occur within the Cuvette d'Andapa in the northeast, at Didy and Torotorofotsy in the center-east, and north of Ranomafana National Park. The water is generally acid and the vegetation low (0.5-1m). At least some of these sites are important for endemic species with restricted geographical ranges or for others that are believed to be rare, such as the Slender-billed flufftail *(Sarothrura waters).*

The most extensive marshes occur at Lake Alaotra, with two types distinguished: permanent fringing marshes, and waterlogged meadows. The permanent marshes are dominated by sedges and *Phragmites,* and may reach a height of 3 m. Western marshes feature fringe-rivers and lakes. The dominant vegetation is *Phragmites* and *Pandanus.* Marshes are drained for riziculture wherever it is possible. Those that remain in the east are generally those that are remote or difficult to drain.

4.3.3. LAKES

Madagascar's principal tectonic lake is Lake Alaotra in the northern part of the central highlands, with an area of 22,000 ha and some 20,000 ha of marshes. During flooding, the lakes can extend to 800 km2; it has been used to irrigate 117,000 ha of rice paddies. Severe sedimentation from hill burning combined with over fishing, agricultural run-off, acidification, (Pidgeon, 1996) and the introduction of exotic species have altered the lake's ecosystem, resulting in a massive reduction in habitat for species such as the Alaotra gentle lemur, two rare birds — the Madagascar pochard and the Madagascar grebe — and for unknown numbers of aquatic species. The population of Aloatra gentle lemurs has declined from 10,000 in 1990 to 3,000 in 2001. The pochard has not been seen since 1991. Sedimentation has led to drainage problems on the cultivated plains, and fisheries' yields declined from around 3,000 tons in 1990 to just 700 tons in 2000 (DWCT 2001).

Madagascar's principal plains lakes lie in the western sedimentary plain, the major lakes being Kinkony and Ihotry. The plains lakes and surrounding marshes are threatened by conversion to agriculture, pasture, and bush fires, over fishing and introduced exotic species. Volcanic lakes are typically deep and steep sided. The principal threats are over-fishing and the introduction of exotic species.

4.3.4. COASTAL AND MARINE ENVIRONMENTS/ECOREGIONS

Madagascar has more than 5,000 km of coastline comprising diverse habitats and ecosystems. In biogeographical terms Madagascar is near the western edge of the Indo-Pacific Marine Ecoregion. Within this, the International Union for the Conservation of Nature places Madagascar in the East Africa Marine Ecoregion comprising the entire tropical east coast of Africa, Madagascar and all other tropical and subtropical Western Indian Ocean Islands.

Participants at the scientific workshop held to define ecoregions for the Protected Area Network identified five distinct zones within the coastal and marine ecoregion. A sixth was added following consultation with marine experts and all are used in the current Plan. These ecoregions are based on physical and biological features common to a given area, and do not necessarily imply distinctive bioclimatic and physical entities.

Western Marine and Coastal Ecoregion

This ecoregion is characterized by extensive sandy beaches, occasional rocky shores, and broad estuaries. The latter supports extensive networks of mangroves. Reef development is patchy and islands are infrequent. The highest priority localities are the Manambolo River mangroves, the Mahavavy River estuary, the Kirindy Mitea coast and the Barren Islands, especially Nosy Mavony.

Southwestern Marine and Coastal Ecoregion

The Southwestern Zone comprises a variety of habitats. The dominant feature of the zone is the extensive reef system, one of the largest in the world. Other important features of the Ecoregion include extensive lagoons, mangroves and long beaches. The highest priority localities comprise the Mikea Coast and Nosy Be with its surrounding coral reefs and lagoons.

4.3.5. HIGH MOUNTAINS ECOREGION

High Mountain localities are those on land over 1,900 m in altitude. This is the approximate elevation at which the characteristically low thicket typical of the Ecoregion is likely to appear. However, it may occur at lower altitudes if climatic and soil conditions are suitable, and conversely montane sclerophyllous forest may occur at and above this nominal altitude. In addition, intact High Mountains zones generally have a high degree of local faunal endemicity that extends across a broader elevational band than that defined by the typical vegetation type found at the highest altitudes.

The High Mountains Ecoregion comprises several localities within Madagascar. One of the most extensive areas occurs in the north in the region of the Tsaratanana Massif, the highest mountain in the country. Another northern site exists further east on the Marojejy Massif.

4.3.6. CENTER ECOREGION

The Center Ecoregion is similar to the Central Domain of Humbert & Cours Dame (1965) and the Central Ecoregion of Schatz (2000), with the exception of the Northern Highlands described earlier. It has been separated from the Northern Highlands based on recent animal distribution information and because it differs in comprising only relatively small and isolated forest blocks, rather than the larger and more continuous forests typical of the Northern Highlands Ecoregion.

The western boundary of the Ecoregion is defined by the 800 m contour of the edge of the Central High Plateau. In the extreme north, the Ecoregion includes the Foret d'Ambre Special Reserve and Montagne d'Ambre National Park. The southern limit follows that of Du Puy & Moat (1996).

4.3.7. SOUTHERN ECOREGION

The Southern Ecoregion has the driest climate in Madagascar. It is bordered by the Eastern, Center and Western Ecoregions. The transition between the Southern and Eastern Ecoregions is rapid. The transitions with the Western and Center Ecoregions appear to be less marked, perhaps explaining the differences in existing models of biogeography.

Rainfall is mostly restricted to a short wet season of no more than four months and may be erratic in the driest areas where droughts are frequent. The entire Ecoregion is arid or sub-arid.

The natural habitats in the Southern Ecoregion vary as a function of substrate type and bio-climate. The wettest areas along the northern and eastern edges of the Ecoregion support the tallest vegetation, except along river valleys throughout the Ecoregion where gallery forests occur. It is perhaps most convenient to consider the Southern Ecoregion as a series of distinctly different habitat sub-regions:

The Mikea Forest in the northwest of the *Ecoregion:* remaining natural habitats within the Mikea Forest are still extensive. There is considerable variation in habitat type, ranging from seasonally dryforest to spiny bush dominated by plants in the Euphorbiaceae and Didieriaceae families.

The limestone Mahafaly Karimbola Plateau: the limestone plateau supports a low, dense bush dominated by Euphorbiaceae and Didieriaceae species. The Radiated tortoise (Geochelone *radiate)* is common in much of the area. There are numerous locally endemic reptile species, and a distinctive assemblage of birds.

Southern and southwestern coastal plain: the flora of the coastal plains is reported to be unique by WWF botanists working in the region. It mostly resembles that of the limestone plateaus in structure, but is more open on sand dunes. The Radiated tortoise is locally common.

Habitats on continental crystalline rock and sand substrates, or volcanic soil: These habitats have been grouped for convenience and to distinguish them from other types. In reality, there may be considerable variation among them depending in part on geographical position.

Exposed coastal areas: coastal margins in the extreme south exposed to prevailing southerly and southeasterly winds may support a dwarf forest that can be less than 30 cm tall. Several locally endemic plant species have been recorded in these habitats.

The Mandrare River basin: recent surveys in this most easterly part of the Ecoregion indicate that the vegetation may include species that spread marginally from the East or Center Ecoregions, especially relatively high areas. Relatively high rainfall may also influence the vegetation structure.

Riverine gallery forest: all larger rivers support a distinctive gallery forest that is taller than the vegetation in surrounding areas. Some animal species may achieve relatively high densities in these sites.

Diversity is relatively low in the Southern Ecoregion compared to others in Madagascar, however distinctive vertebrate communities are also recorded.

4.3.8. NORTHERN HIGHLANDS ECOREGION

The Northern Highlands are combined with either the Eastern or the Center Ecoregions in other existing models. The Northern Highlands are considered to be separate from the Center. This is justified in part on practical grounds concerning conservation management: the Northern Highlands comprise rather large continuous blocks of forest whereas the Center is typified by smaller, isolated blocks.

Furthermore, recent research indicates that the Northern Highlands may have a distinct fauna. The northern and western limits of the Ecoregion are defined by the 800 m altitude line on the northern flanks of the Central High Plateau. The eastern edge is difficult to determine, but the Ecoregion includes the Marojejy Massif. The southern limit is defined somewhat arbitrarily as there is little remaining natural habitat on that part of the Central High Plateau.

4.3.9. WESTERN ECOREGION

The Western Ecoregion has two geographic sub-units: a smaller area in the extreme north with the exception of the upper slopes of the Montagne d'Ambre Massif, and an extensive region to the west and south of the Central High Plateau until the Southern Ecoregion is encountered.

The Western Ecoregion is marked by a reliable wet season of up to five months and a distinct dry season when rainfall is highly infrequent. Plant communities show a marked degree of deciduousness during the dry season.

The flora and vegetation are significantly influenced by variations in soil type and geology. In general, five major soil/substrate types are recognized.

Volcanic soils or base rock. The vegetation on this fertile substrate is generally among the tallest and at times the densest within the Ecoregion. Volcanic substrates are localized and occur west of the Tsingy de Bemaraha Massif and in the extreme north. Some of the northern forests are unusual insofar as they are in canyons where permanent underground water exists, giving rise to evergreen formations.

Clay soils. The vegetation is similar to that found on volcanic substrates.

Limestone and calcareous soils. Plant communities show adaptations to prolonged seasonal dryness on the porous calcareous substrates. Succulents are numerous and many water storage adaptations are observed. Vegetation is generally low and sparse. Local endemism may be significant, and each major Tsingy (heavily eroded pinnacle limestone) region may support several unique taxa.

Sandy soils. The vegetation may show a general similarity to that occurring on volcanic substrates, but adaptations to: drier conditions are generally more evident. Canopy height may also be somewhat less.

Riverine alluvial soils. Riverine gallery forests are generally distinct from neighboring vegetation formations. Trees are often less deciduous and there may be a dominance of Tamarindus indica and

Eugenia sakalavarum. Canopy height may exceed 25 m, particularly where water is permanently accessible to roots.

While overall bioclimatic conditions and substrate types are useful predictors for flora and variation, other factors such as retention of surface waters, soil depth and open rocky conditions may produce marked localized variations. A clear example occurs in Ankarana where tall, essentially evergreen forest grows on deep soils over

an accessible water table, whereas adjacent vegetation on shallow soils in rocky areas is low, deciduous and typified by succulent species. Proximity to the coast may also have an influence, as well as exposure to prevailing moisture-bearing onshore winds.

Sub-regional and local diversity and endemism are marked in the Western Ecoregion. In part this is associated with the differing substrates listed above. For example limes tone Tsingy areas have numerous locally endemic plant and animal species.

Other patterns of local endemism and diversity are linked to factors that are less easily accounted for. The factors may include geographical isolation and historical changes in climatic conditions that lead to expansion or contraction of different vegetation types. Some of the known or suspected centers of diversity and/or endemism are:

The extreme northern isolate. Several locally endemic plants are confined to this area, including two baobabs and several succulent Euphorbiaceae. However, it is not considered to be a distinctive subregion except that Schatz (2000) recognizes a distinctive bioclimatic sub-region near the city of Antsiranana. There is a case for considering the extreme north as a distinctive faunal sub-region based on vertebrates. The northern primates, for example, include several locally endemic species or subspecies, several of which are more closely associated with Eastern or Northern Highlands taxa.

The northwest. The northwestern sector of the Ecoregion has several animal taxa that are locally endemic. Some are restricted to relatively small areas including the Ankarafantsika Massif or the forests around the Baie de Baly, whereas others are more widespread in the sector. Ankarafantsika has a significant number of locally endemic vertebrate species.

Bemaraha and Manambolomaty Complex. The Bemaraha Massif and surrounding forests immediately to the west support a significant range of locally endemic vertebrates. Some of these taxa are related to Eastern forest species, indicating range expansion and subsequent isolation during periods of climatic change.

Menabe. The extensively studied Menabe sub-region between the Morondava and Tsiribihina Rivers is a recognized center of local endemism and diversity. Part of its importance in terms of diversity may be linked to the presence of Southern and Western biotas that come together in the Menabe area. However, it is also associated with the presence of several locally endemic species that are of high conservation importance.

The patterns of diversity and endemism are variable in the Western Ecoregion, and appear to be inconsistent between different taxonomic groups. It is clear that the larger rivers are barriers to certain taxa, but their influence on different species or sub-species is inconsistent. Among primates, for example, the Betsiboka River is a barrier to two Sifaka sub-species but does not block the Mongoose lemur.

The Western Ecoregion is best considered to have a continuous turnover of taxa throughout its geographical range. Recent studies indicate that all sites that have been examined have at least a few unique species not known from elsewhere.

4.3.10. Unique Isolated And Transitional Habitats

Many Malagasy habitats are "transitional" insofar as there is a continuum of bioclimatic change throughout much of the island. However; there are several areas that do not easily fit into any of the more widely accepted models, and some appear to have a significant number of locally endemic taxa.

Three isolated or transitional habitats are:

- Northern Transitional Zone

- Analavelona, an elevated and isolated forest in the southwest surrounded by Southern Ecoregion habitats, and
- The area around the Ranopiso Pass, part of the transition between the Eastern and Southern Ecoregions.

Each has a number of unique locally endemic taxa. The zones may be best considered as ecotones (areas transitional between two recognized ecoregions).

4.3.10.1. Habitats, Diversity And Endemism

Northern Transitional Zone

The Northern Transitional Zone includes the classically recognized Sambirano Domain of Humbert & Cours Dame (1965), together with habitats occurring below 800 m on the slopes of the Northern Highlands. The Sambirano is home to several locally endemic taxa, at least among animals. Some other areas such as Daraina in the northeast also support locally endemic taxa. These transition areas comprise at least two separate bioclimatical zones: the northwest (Sambirano) and the northeast near Daraina and Vohemar.

Ranopiso

Several blocks of natural habitat occur in this abrupt transition zone. Several occur as altitude bands on rugged mountain slopes. The zone is considered separately as it is difficult to classify as either Eastern or Southern ecoregion. It also supports several locally endemic species with limited ranges. Rare, locally endemic species are particularly restricted to isolated summit areas where the forests are more humid than those that surround them.

4.3.10.2. Protected Areas

Part of the Manongarivo Special Reserve and the Lokobe Strict Nature Reserve cover the Northern Transitional Zone in the northwest. The lower slopes of the Tsaratana'na Strict Nature Reserve occur in the ecoregion recognized by some authorities as the Sambirano. A new site near Daraina is proposed in the northeast that includes three major forest blocks. Although Sahamalaza to the west of the Transition Zone has been proposed mainly as a protected area for coastal habitat conservation, the site is also considered to be important in terms of representing a distinct terrestrial ecological community marked by the presence of Eulemur macaco flavifrons, even though the sites' habitats are degraded.

Analavelona is not a protected area but local people are favorable to conferring an adequate legal status to ensure that it is safeguarded. The staff of Zombitse vohibasia National Park is supporting the communities in this endeavor. The Ranopiso Transitional Zone is partially protected within part of Parcel II and all of Parcel III of Andohahela National Park. Biologists familiar with the area do not consider that this ensures adequate biodiversity representation, and additional sites will be prospected.

4.4. Madagascar's National Parks, Reserves, And Protected Areas

In 1927 the French colonial government introduced the first protections for natural sites to Madagascar. The original sites were meant for conducting scientific research. Over the years Madagascar's government has followed the example of its predecessor and has reserved more sites and parks. Masoala is the largest at 2,405 square kilometers, while the oldest, including Lokobe, were formed under French Colonial rule.

Marine and coastal protected areas include Mananara (Nosy Atafana) National Park within the Mananara-nord Man and Biosphere Reserve together with three marine parks incorporated within the Masoala National Park. All are in the northeast. Manombo Special Reserve in the southeast is also coastal but has so far involved only forest conservation.

The island of Nosy Tanikely has been declared a protected area by the authorities on neighboring Nosy Be, but has no legal status. In the southwest, the village of Anakao has agreed to set aside two small areas of coral, lagoon and the island of Nosy Be for conservation and tourism. A recent initiative to develop new marine national parks within Man and Biosphere Reserves includes Nosy Be and the Nosy Hara archipelago in the northwest

Marine and coastal ecosystems are clearly under-represented in the existing national protected area system. Those that exist protect a small fraction of the country's coral reef, lagoon, mangrove and littoral forest ecosystems.

4.5. FORESTS

Malagasy forests comprise 4,220 known species of trees and large shrubs. An analysis of the tree flora reveals that 33 percent of the 490 indigenous genera with tree species are endemic to Madagascar, including the Comoro Islands. The 329 non-endemic genera are represented by an additional 3,280 species of trees and large shrubs, of which 95 percent are endemic (Schatz in Lauren) and Goodman, 2000).

Madagascar's flora accounts for about 12,000 species, out of which approximately 10,000 species are forest dependent; 81 to 86 percent of these are endemic. Madagascar alone harbors a higher number of orchid species than does the whole of Africa. A substantial proportion (33 percent) of the native flora consists of trees or shrubs, of which 96 percent are endemic. Most of the remaining native flora is forest-associated.

Dry forests in the southwest comprise more than 1,000 species of which more than 90 percent are endemic (Toliara Biosphere Proposal, ONE 2001). Unusually for littoral vegetation, the dune bush of southwest Madagascar comprises at least 112 species, 95 percent of which are endemic.

4.6. PROTECTED AREAS

The Tsaratanana, Marojejy and Andringitra Massifs, and the highest points of the Anosyenne Mountain chain, are largely or partly within protected areas. However, the uniqueness of environments in this ecoregion, and the high levels of diversity and endemism justify further protected area coverage.

Tsaratanana Massif: recent evidence suggests that this site may be one of the richest localities for reptiles and amphibians, and it has a rich variety of forest and high altitude habitats. The Tsaratanana Strict Nature Reserve provides only partial legal protection for the higher elevation areas, and it may be of value to extend it.

Natural vegetation areas at higher altitudes between Tharatanana and Marojejy – Anjanaharabe Sud protected areas: numerous high peaks occur in this area that may be crowned at their summits by High Mountains habitats distinct from the more extensive forest cover at lower altitudes. As these may be important centers of endemism and or diversity, measures to provide adequate protection may be required within an eco-regional conservation and development program.

Marine and coastal protected areas that exist already include Mananara (Nosy Atafana) National Park within the Mananara-nord Man and Biosphere Reserve together with three marine parks incorporated within the Masoala National Park. All are in the northeast. Manombo Special Reserve in the southeast is also coastal but has so far involved only forest conservation.

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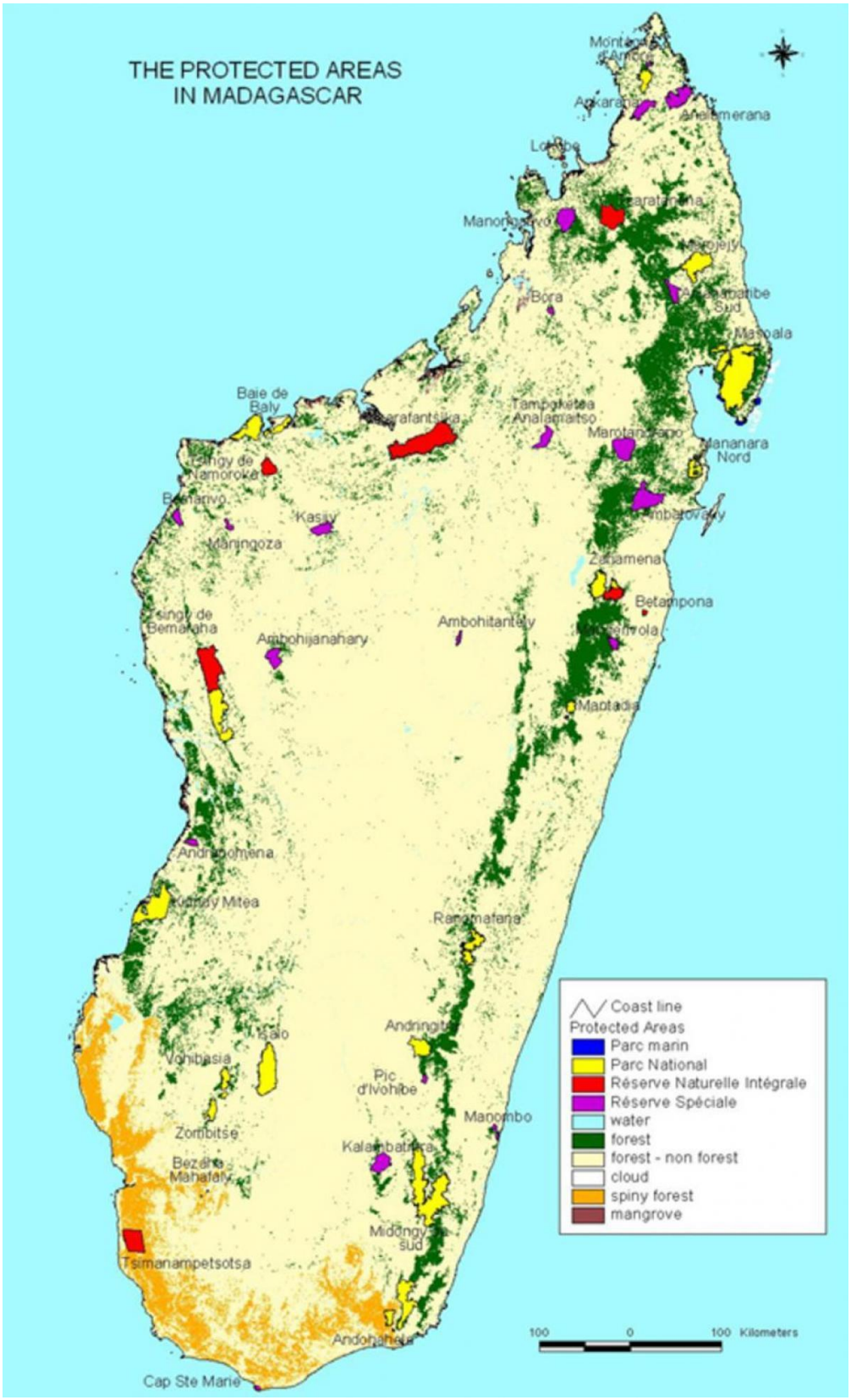
Table 3: List of Madagascar protected areas[6]

National Parks, Reserves, And Protected Areas of Madagascar	Area
Ambatovaky Reserve	148,387 acres
Amber Forest Reserve	11,886 acres
Amber Mountain National Park	44,973 acres
Ambohijanahary Reserve	61,159 acres
Ambohitantely Reserve	13,838 acres
Analamazaotra National Park(Périnet)	38,252 acres
Analamerana Reserve	85,746 acres
Andasibe-Mantadia National Park	38,252 acres
Andohahela National Park	187,849 acres
Andranomena Reserve	15,864 acres
Andringitra National Park	76,998 acres
Anjanaharibe-Sud Reserve	79,296 acres
Ankarafantsika National Park	333,592 acres
Ankarana Reserve	45,035 acres
Baie de Baly National Park	141,200 acres
Bemarivo Reserve	28,590 acres
Betampona Reserve	7,215 acres
Beza Mahafaly Reserve	1,483 acres
Bora Reserve	11,962 acres
Cap Sainte Marie Reserve	4,324 acres
Fandriana Marolambo Forest Corridor	480,098 acres
Isalo National Park	201,490 acres
Kalambatritra Reserve	69,819 acres
Kasijy Reserve	48,927 acres
Kirindy Mitea National Park	178,410 acres
Lokobe National Park	3,763 acres
Mahavavy-Kinkony Protected Area	682,010 acres
Mananara Nord National Park	355,832 acres
Mangerivola Reserve	32,136 acres
Maningoza Reserve	19,521 acres
Manombo Reserve	13,146 acres
Manongarivo Reserve	80,890 acres
Marojejy National Park	148,387 acres
Marolambo National Park	480,098 acres
Marotandrano Reserve	104,278 acres
Masoala National Park and Nosy Mangabe Reserve	594,338 acres
Midongy du sud National Park	474,932 acres
Montagne des Français Protected Area	15,053 acres
Nosy Hara National Park	452,477 acres

[6] https://www.worldatlas.com/articles/madagascar-s-national-parks-reserves-and-protected-areas.html

National Parks, Reserves, And Protected Areas of Madagascar	Area
Nosy Tanikely National Park	773 acres
Nosy Ve-Androka National Park	4,853 acres
Pic d'Ivohibe Reserve	8,532 acres
Ranomafana National Park	102,798 acres
Sahamalaza National Park	64,247 acres
Tampoketsa Analamaitso Reserve	42,379 acres
Tsaratanana Reserve	120,148 acres
Tsimanampetsotse National Park	106,750 acres
Tsingy de Bemaraha National Park	178,756 acres
Tsingy de Bemaraha Reserve	210,953 acres
Tsingy de Namoroka National Park	54,924 acres
Zahamena National Park	104,526 acres
Zahamena Reserve	54,610 acres
Zombitse-Vohibasia National Park	89,719 acres

Figure 2; Madagascar Protected Areas



4.7. AGRICULTURE AND ORGANIC FARMING

Agriculture, including fishing and forestry, is a mainstay of the economy. Major exports are coffee, vanilla (Madagascar is the world's largest producer and exporter of vanilla), sugarcane, cloves, cocoa, rice, cassava (tapioca), beans, bananas, peanuts and livestock products. There is extensive use of chemicals in the cultivation of sugar cane and rice and organic farming is not practiced in a scale that would be considered significant.

4.7.1. ORGANIC FARMING

Madagascar's organic sector started small. . A lack of knowledge in production, certification, processing and export continues to inhibit growth

However a desire to develop the sector is noted for organic crops and spices even if the main crop is rice with efforts to organize a viable organic sector continue among private enterprise and aid group,

4.7.2. BEE KEEPING

Bee keeping is still practiced in Madagascar through the traditional methods; however there are efforts by several non-governmental organizations to promote the modern techniques of bee keeping. Some NGOs for example are supporting a bee-keeping project in Ambohimahamasina which aims to increase villagers' incomes whilst also promoting forest conservation. The project has successfully trained 50 collectors of wild honey in modern beekeeping methods, thereby improving honey production & removing the need to collect wild honey - which often destroys the queen bee & her colony as well as forest trees.

Madagascar contains and represents many unique and treasured environments, and is part of our world heritage hat must be preserved. The people are part of this environment, and they must be cared for as well. PMI-sponsored IRS has a strong record of IRS execution without environmental degradation, and it is highly likely that with continued adherence to the environmental mitigation and monitoring plan, which is key to this history of success, that implementing contractors will continue to deliver life-saving IRS with insignificant environmental impact. Therefore, it is recommended that IRS be permitted to continue, and to be allowed in the buffer zones of the protected areas that Madagascar has, and continues to establish.

5. ENVIRONMENTAL AND HEALTH IMPACTS

5.1. POTENTIAL POSITIVE EFFECTS OF THE IRS PROGRAM

5.1.1. DIRECT POSITIVE EFFECTS

The direct positive impacts of the IRS program are the reductions in child and adult malaria morbidity and mortality, which 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: miscarriage; low birth weight; adverse effects on fetal neurodevelopment as a result of exposure to malaria; and 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.

5.1.2. 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-Madagascar 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 among children of school going age[7], 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[8].

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 operations site building 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 and significant magnification effects.

The Madagascar PMI VectorLink project views gender equality and female empowerment as development goals in their own right, as well as approaches that accelerate vector control. VectorLink Madagascar will mainstream gender across its operations, in line with the project's gender strategy, with an emphasis on women's economic empowerment through employment in its IRS and entomology operations. To achieve this goal, the project will implement policies that promote the hiring of female seasonal workers and ensure a safe and respectful workplace for all.

[7] https://www.worldbank.org/content/dam/Worldbank/Feature%20Story/Africa/afr-marie-anne-valfort.pdf

[8] https://www.path.org/media-center/fighting-malaria-in-the-workplace/, Accessed 7/15/19

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

5.2. 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. Potential adverse impacts are listed below.

5.2.1. Direct Potential Adverse Effects

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, organophosphates, clothianidin 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.

Potential Impacts to Non-Target Organisms from Pesticides

Table 4 in Section 5.5 of this SEA documents the degree of toxicity of the six WHO PQ-recommended pesticide classes, to birdlife, aquatic life, and insects, as well as pesticide persistence and bio-accumulation potential.

Potential Impacts to Endangered Species

It is USAID policy to conduct its assistance programs in a manner that is sensitive to the protection of endangered or threatened species and their critical habitats. The Initial Environmental Examination for each project, program or activity having an effect on the environment shall specifically determine whether the project, program or activity will have an effect on an endangered or threatened species, or critical habitat. If the proposed project, program or activity will have the effect of jeopardizing an endangered or threatened species or of adversely modifying its critical habitat, the Threshold Decision shall be a Positive Determination and an Environmental Assessment or Environmental Impact Statement completed as appropriate, which shall discuss alternatives or modifications to avoid or mitigate such impact on the species or its habitat. This document, along with its Annex A Environmental Mitigation and Monitoring fulfills those requirements.

IRS is not likely to adversely impact threatened or endangered species, or their critical habitat, due to the fact that spraying activities are conducted indoors only, and are carefully structured to avoid fugitive spray to the outdoors. Any openings to the outside of the house are closed up or avoided during spray. Structures with gaps between wall coverings are ineligible for IRS. Finally, storage and disposal facilities are sited at least 100 meters from any sensitive areas such as habitat for endangered or protected species. Although IRS team may pass through these areas to reach targeted areas for spraying, mitigation measures include putting insecticides in hermetically sealed barrels. it is expected that spray operations will be according to BMPs, and the total pesticide load on the environment is expected to be the minimum possible.

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. Modern methods of beekeeping have developed throughout Madagascar, as evidenced by the creation of many beekeeping centers offering various services (training in modern apicultural techniques, production and sale of honey, supervision of groups and/or apicultural associations, etc.) The project will identify locations where beehives are kept, and observe a 30- meter no-spray buffer zone around them. Bee-hive owners will be advised accordingly.

However specifics precaution are taken and in accordance with beekeeping actors and a buffer zone of 30 meters is observed between the sprayed structures and the identified hives.

5.2.2. Indirect Adverse Effects

Upon termination of the IRS program, PMI will properly dispose of the IRS equipment and will no longer supervise its use. IRS equipment that may be donated to district health officials includes backpack compression sprayers, used or clean boots, PPE, 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 Government of Madagascar (GoM), 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 PMI and/or the IP, requires that PMI and/or the PMI IP provide environmental training to the GoM in the PMI IRS BMPs, and 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 GoM, these activities must be mentioned in the annual Letter Report, in addition to this SEA. These activities do not require environmental compliance monitoring, however, PMI and/or the PMI IP must provide training in the PMI IRS BMPs.

The conduct of IRS by District Medical Officers with communities, using properly working equipment left behind by PMI may temporarily, and in a minor way increase the total pesticide load on the environment. However, since the IRS equipment will be in operable condition and capacity has been built among the District Medical Officers, it is expected that spray operations will be according to BMPs, and the total pesticide load on the environment is expected to be less than if the donation is not made.

5.3. Human Exposure Risks/Impacts

Worker and Resident Exposure Pathways

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. Exposure risks of all WHO-recommended pesticides in relation to cancer and non-cancer endpoints are presented in IVM updated PEA 2017. 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.

5.3.1. Pre Spraying Exposure Pathway

Preparing pesticide solutions during the IRS requires putting the pesticide in the spray pump and agitating it to ensure ample mixing with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, from releases of pesticide vapors and liquids. Vapor releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapors 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.

5.3.2. Exposure During Spraying

Inhalation of aerosol droplets 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 organophosphates, 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.

5.3.3. Exposure During Disposal (Including Progressive Rinsing)

Disposal is a key issue with IRS intervention that uses 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 of residents who come in contact with the soil or water in which the pesticide was disposed. Once the pesticide gets into the soil, it can migrate to groundwater, which may be used as a water supply via household wells. In this manner, ingestion exposure can occur from drinking contaminated surface water. Residents may also be exposed to this contaminated water by dermal contact when it is used for cleaning or cooking purposes.

5.3.4. 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.

5.4. Pesticide- and Process-specific Potential Health Impacts

The potential health impacts of the insecticide products that can be used for IRS are described in detail in the PMI Programmatic Environmental Assessment for Integrated Vector Management Programs for Malaria Vector Control (2012 and 2017 Updates). A summary of these effects is given in Annex E of this SEA.

5.5. Cumulative Impact

Organophosphates are the pesticides with the highest potential for cumulative impacts. Pyrethroids, carbamates, clothianidin and most organophosphate formulations break down readily in the environment, limiting the risk of cumulative environmental impact, especially if disposal sites are well chosen and BMPs are followed.

However, repeated human exposures to organophosphates result in cumulative cholinesterase depression, with increasingly severe effects. For this reason it is exceptionally important that PPE be worn properly and at all times when pesticide contact is possible. It is also incumbent upon team leaders to monitor the health of their spray operators on a daily basis, and to look for any signs of cholinesterase depression. 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.

There are indications that the capsule suspension form of Actellic is more resistant to environmental degradation than either Actellic Emulsifiable Concentrate or the other WHO PQ-recommended pesticides. This may result in a temporary build-up of concentration within the soak pit prior to degradation.[9]

[9] Mitchell, David, et al, (2015).

6. PESTICIDE PROCEDURES

The PMI document Integrated Vector Management Programs for Malaria Vector Control Programmatic Environmental Assessment updated in 2017 analyzed all WHOPES and WHO-PQ recommended insecticides, and takes in consideration 12 factors when a project includes "assistance for the procurement or use, or both, of pesticides." As the PMI Madagascar IRS program includes assistance in both of these aspects, it is subject to this regulation. This section therefore addresses each of the 12 factors for the IRS Malaria Control Program in Madagascar for all WHO-recommended pesticides in the pyrethroid, carbamate, organophosphate, neonicotinoid classes and the clothianidin/deltamethrin combination; as well as chlorfenapyr (pyrrole class) when recommended by the WHO PQ for the period 2019 – 2023.

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

All WHO-recommended pesticides registered and/or accepted for use for IRS or a similar use in the United States and the host Madagascar government in the pyrethroid, carbamate, organophosphate and neonicotinoid classes, as well as the pyrrole class when PQ listed, will be preferred in this IRS project. Some of the pesticides on the WHO PQ list are not registered with the United States Environmental Protection Agency (USEPA) for economic, technical, or regulatory reasons. There is a very limited market in the US for IRS, and as a result, registrations for this use of these pesticides have been voluntarily withdrawn, or never filed. However, US 22 CFR 216.3(b) (1) (iii) allows the use of pesticides not registered for the same or similar use by USEPA, provided that:

1. The proper assessments are performed.
2. The assessments include an evaluation of the factors in Sections 5.1–5.11of this document.
3. Notification is provided to, and authorization received from, the host Madagascar government for the use of the pesticide in Madagascar.

PMI works closely with host Madagascar government, with full and clear disclosure, as well as providing any necessary assistance in the mitigation of risk from the use of these WHO PQ pesticides. This SEA, supported by the PMI IVM PEA, and distributed to Ministries of Health, Environment, and Agriculture, provides the assessment, notification, and mitigation requirements of U.S. regulations. PMI is therefore empowered, upon acceptance of this document and the receipt of formal authorization from a competent Malagasy authority, to use in Madagascar all WHO PQ-recommended pesticides in the pyrethroid, carbamate, organophosphate and nicotinoid classes, and the clothianidin/deltamethrin combination; as well as chlorfenapyr when recommended by the WHO PQ.

6.2. THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

In addition to the above criteria, insecticide selection for any PMI supported program is subject to the following considerations.

6.2.1. PRIMARY CRITERIA FOR CHOOSING PESTICIDES

Approval by the WHO: Only insecticides recommended by the WHO PQ team or by USEPA can be used in IRS. Certain pesticides in the organophosphate, carbamate, pyrethroid, neonicotinoid, organochlorine classes and the clothianidin/deltamethrin combination are WHO PQ-recommended for use in IRS. Chlorfenapyr is

not yet recommended by WHO, but authorization is requested in this SEA to use it for hut trials, and for IRS when and if it receives a WHO PQ listing[10].

Registered for use in Madagascar: In the case where the insecticide proposed for use in IRS is not registered in Madagascar, PMI will work with manufacturers and distributors, as well as the Ministry of Health to obtain special authorization for the use of the pesticide. All WHO-recommended insecticides are accepted for use in Madagascar by the competent authority.

Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area: All pyrethroids, carbamates, clothianidin and organophosphates are expected to stay active and effective for 3 to 6 months after application; however, the effective duration varies under different climatic conditions and other factors.

Appropriate for use on the wall surfaces of the selected location: In Madagascar the majority of the houses in rural settings are still made up of mud wall surfaces, mud bricks, and burnt bricks; the remainder, found largely in urban areas, are made with cement. Pyrethroids, carbamates, clothianidin and organophosphates are known to function well on these surfaces, and are therefore appropriate for use.

Local vector susceptibility to the insecticide: Resistance to insecticide develops when a hereditary feature is selected in an insect population that reduces the population's sensitivity to a given insecticide. In Madagascar, vector susceptibility studies have confirmed the susceptibility of pirimiphos-methyl and clothianidin in most districts.

Monitoring Vector Susceptibility to Insecticides in Madagascar (2018):

The results of the vector susceptibility tests indicated full susceptibility of *An. gambiae* s.l. to pirimiphos-methyl, clothianidin and bendiocarb in all areas where the tests were conducted.

The test results also showed that *Anopheles gambiae* s.l. has started developing resistance to permethrin in Ambodifaho, Vavatenina, Vohitrambato and Betaindambo, to alphacypermethrin in Ambodifaho, and Vohitrambato, to deltamethrin in Vohitrambato and Betaindambo and to lambdacyhalothrin in Vohitrambato.

Suspected resistance was noted for deltamethrin in Ambodifaho and for permethrin in Manambotra Sud.[11]

The objectives of the entomological surveillance were:

- To identify the vector species, composition, and density;
- The objectives of the entomological surveillance were:
- To identify the vector species, composition, and density;
- To determine vector biting and resting behavior;
- To determine the quality of spraying and insecticide decay rate following spray operations; and
- To ascertain vector susceptibility to the WHOPQ classes of insecticides, including chlorfenapyr.

Entomological surveillance plays a critical role as it allows vector control programs to make informed decisions. The impact of IRS on vector density, resting and feeding behavior will help identify effective insecticides against local vectors to guide vector control programming.

Ecological impact: Madagascar boasts of a diverse wildlife throughout the country, but especially in the national parks and protected areas, and it is extremely important that IRS does not in any way diminish this biodiversity. The potential ecological impact of the WHO PQ pesticides is well documented, most recently in the 2017 PMI IVM PEA. However, if BMPs for IRS are strictly followed, the release to the environment, and

[10] http://www.who.int/pq-vector-control/prequalified-lists/en/

[11] 2018 PMI VectorLink Madagascar Final Entomological Report

therefore the impact to the environment, should be negligible. More information on ecological impact of the proposed pesticides is found in Section 6 as well as other sections of this document.

Climate impacts of insecticides have been identified using screening tools and integrated in the Work Plan development, with an action plan to ensure that climate risks are properly accounted for, and addressed.

Human health impact: The 2012 and 2017 updated IVM PEA assessed cancer and non-cancer risks associated with all WHO PQ-recommended insecticides by process (e.g., mixing insecticide, spraying, residing in sprayed house) and pathway (e.g., inhalation, dermal, ingestion), and cancer risks by process and pathway where available (mainly for DDT and select pyrethroids). In general, pyrethroids and carbamates pose fewer non-cancer risks via any pathway than organophosphates when risks are assessed, but the risks of organophosphates can be managed by following standard PMI IRS procedures and protocols (BMPs).

6.2.2. SECONDARY SELECTION CRITERIA

- 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 Madagascar
- Technical assistance with training and troubleshooting by supplier

6.3. THE EXTENT TO WHICH THE PROPOSED PESTICIDE USE IS PART OF AN INTEGRATED PEST MANAGEMENT PROGRAM

Integrated pest management is defined 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. 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."

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

Use of IVM for the control of the malaria vector population is practiced using two primary interventions, insecticide-treated nets and indoor residual spraying. Environmental management for malaria control is limited to some-common sense safeguards, such as limiting standing water, which can serve as a breeding ground for mosquitoes. PMI does not support environmental management as a malaria vector control method. Because of the life-cycle requirements and the adaptability shown by malaria vectors, these practices have not demonstrated large-scale effectiveness.

PMI strategy has been that IRS will be implemented as a component of IVM for malaria control. PMI supports an evidence-based approach and will continue to review health management information systems and entomologic data to determine where best to deploy IRS.

6.4. The Proposed Method or Methods of Application, Including Availability of Appropriate Application and Safety Equipment

IRS under PMI funds involves spraying a WHO recommended insecticides with long-lasting residual activity on indoor wall and ceiling surfaces where mosquitoes usually rest. The pesticide then dries up and can leave a crystalline deposit on the sprayed surface. A lethal dose of the insecticide is absorbed when the mosquito rests on the surface, which kills the mosquito.

WHO-recommended pesticides in the pyrethroid, carbamate, organophosphate, neonicotinoid classes and the clothianidin/deltamethrin combination; as well as chlorfenapyr (pyrrole class) when recommended by the WHO PQ will only be applied using pressurized spray equipment approved for the pesticide in use, by trained spray operators wearing gloves, overalls, hard hats with face shields, neck shields, and boots. All necessary PPE for this activity is supplied by PMI, and its use is supervised and enforced throughout the course of the campaign. Spray operators are trained in and use spray patterns that have proven effective in providing long-lasting toxicity toward the malaria vector mosquito.

The spray operators who implement IRS use 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. After the day's spraying is complete, spray operators clean the sprayer following PMI BMPs to maintain proper functioning of the pump, reuse leftover pesticide on the following day, and guard against release of and/or exposure to pesticides. They also follow the manufacturer's recommendations to ensure their proper operation and calibration.

6.5. Acute and Long-Term Toxicological Hazards Associated with the Proposed Use, and Measures Available to Minimize Such Hazards

The IVM PEA assessed the toxicity of WHO-recommended IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and other aquatic organisms. The table below provides graphic information on the toxicity and some of the other characteristics of the WHO PQ pesticides. In general, most of them are toxic to bees, fish, and other aquatic organisms, and less so to mammals and birds.

"Indoor" being an important operative word in IRS, the risks to biodiversity from spray operations are minimal if PMI BMPS are followed. The BMPs have been designed to prevent any significant release to the environment, and a strong, automated, smart-phone-based supervisory system ensures that BMPs are followed or non-compliance is immediately corrected. The reader is referred to Annex E of the 2017 IVM PEA, and to Chapter 5 of this SEA for greater detail about pesticide toxicity.

Table 4: The degree of toxicity of the WHO PQ-recommended IRS pesticide

IRS Insecticide	Mammal	Bird	Fish	Other Aquatic	Bee	Persistence	Bioaccumulate
Alpha-cypermethrin (P)							
Bendiocarb (C)							
Bifenthrin (P)							
Cyfluthrin (P)							
DDT (OC)							
Deltamethrin (P)							
Etofenprox (P)							
Fenitrothion (OP)							
Lambda-cyhalothrin (P)							
Malathion (OP)							
Pirimiphos-methyl (OP)							
Propoxur (C)							
Chlorfenapyr (PR)							
Clothianidin (N)							

Source: IVM PEA 2012 and 2017

Key

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

HAZARDS

The two broad categories of hazard are release and exposure to humans and domestic animals, and releases causing environmental damage. Release and exposure may occur at any point, from the production or importation of the pesticide through transportation, storage, distribution, pesticide loading into tanks, spray application, clean-up, and final disposal, as well as after spraying due to improper spray deposition on household articles, or improper behavior of beneficiaries regarding sprayed surfaces.

In humans, both organophosphates and carbamates can produce cholinesterase depression if the proper protective measures are not used and exposure results. Cholinesterase inhibition results in overstimulation of the nervous system, with symptoms that include nausea, dizziness, confusion, and at very high exposures

respiratory paralysis and death (U.S. EPA, 2000b). The two classes of insecticides differ in their impacts on human health in that with carbamates the cholinesterase inhibition is temporary, and may dissipate in as little as 2-3 hours, providing the exposure is eliminated. With organophosphates, the inhibition is longer-lasting and cumulative, and thus more dangerous. However all potential environmental threats are noted and monitored along with planned mitigations measures for the safe use of pesticides. Details of specific environmental threats and activities needing precaution are listed with mitigation measures in Section 7 and Annex A.

6.6. The Effectiveness of the Requested Pesticide for the Proposed Use

Pesticides are selected for IRS based on technical efficacy and economic efficiency in the intended use, along with other extrinsic variables. Complete selection criteria can be found in Section 6.2 of this SEA. 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 vector 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.

6.6.1. Vector Resistance

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. 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 should cover).

Prior to each campaign, it is necessary to measure vector resistance in the target areas, to ensure that acceptable kill levels will be achieved. A resistance monitoring program has been established by the VL Madagascar Entomological team in collaboration with the PMI-supported VectorLink Madagascar project, and the results from this ongoing program are the primary determinants of the choice of pesticide and other supplementary actions.

Pyrethroids, carbamates, clothianidin and organophosphates that have not developed resistance in Madagascar are expected to stay active and effective for 3 to 6 months after application; however, the effective duration varies under different climatic conditions and other factors. Three pyrethroids, known as longer-lasting pyrethroids, can last up to 11 months, based on various field trials. For this reason, pyrethroids have traditionally made the best choice for extended seasons. However, in order to manage vector resistance, it has proven to be necessary to switch the class of pesticides used in IRS.

In Madagascar vector susceptibility was tested for insecticides recommended for public health and used for IRS and the impregnation of LLINs (carbamates, pyrethroids, organochlorines, and organophosphates). The tests were performed using the World Health Organization (WHO) tube assays with insecticide-impregnated papers on two- to four-day- old adult, non-blood-fed female mosquitoes (reared from field-collected larvae). Mortality was recorded after a 24-hour holding period. The 2016 WHO resistance classification criteria was used to interpret susceptibility test results.

The WHO susceptibility test in 2018 results of the vector susceptibility tests indicated full susceptibility of *An. gambiae* s.l. to pirimiphos-methyl, clothianidin and bendiocarb in all areas where the tests were conducted.[12]

The test results also showed that *Anopheles gambiae* s.l. has started developing resistance to permethrin in Ambodifaho, Vavatenina, Vohitrambato and Betaindambo, to alphacypermethrin in Ambodifaho, and Vohitrambato, to deltamethrin in Vohitrambato and Betaindambo and to lambdacyhalothrin in Vohitrambato.

Suspected resistance was noted for deltamethrin in Ambodifaho and for permethrin in Manambotra Sud.

In 2018, the CDC bottle assay using chlorfenapyr against wild Anopheles gambiae s.l. was repeated, ensuing the results below:

- 100% mortality of *An. gambiae* s.l., one day after a 60-minute exposure to chlorfenapyr at 50µg/bottle in Ambodifaho
- 100% mortality of *An. gambiae* s.l., two days after a 60-minute exposure to chlorfenapyr at 50µg/bottle in Manambotra Sud, Lanivo.
- 100% mortality of *An. gambiae* s.l., three days after a 60-minute exposure to chlorfenapyr at 50µg/bottle in Betaindambo, Mahatsinjo and Ampasimpotsy.
- 100% mortality of *An. gambiae* s.l., recorded in all the sites after a 60-minute exposure to chlorfenapyr at 100µg/bottle and 200µg/bottle.

6.6.2. VECTOR BEHAVIOR[13]

VectorLink Madagascar entomologists and vector control officers collected a total of 10,714 mosquitoes from all the sentinel sites between June and December 2018 in the South East, and between August and December 2018 in the East and South West of Madagascar, using Human Landing Catch (HLC), indoor Prokopack aspiration (PSC) and outdoor resting collection (ODC) with aspirators. Listed below are the number and proportion of mosquitoes collected per sampling method:

- HLC: 9,562 (89.3%)
- PSC: 310 (2.8%)
- ODC: 842 (7.9%)

42.6% (4,565) of the total mosquitoes collected were anophelines and 69.8% (3,186) represented the malaria vectors or potential vectors in Madagascar: *Anopheles gambiae* s.l., *Anopheles funestus* group, *Anopheles mascarensis*, and *Anopheles coustani*. *Anopheles gambiae* s.l., *An. funestus* and *An. coustani* were collected at all sentinel sites and *An. gambiae* s.l. was observed as the primary and predominant vector species in the IRS areas. *Anopheles mascarensis* was collected in Ambodifaho, Vohitrambato, Vavatenina, Lanivo and Lopary.

The HLC data revealed an exophagic tendency in all sites. When HLC data from all the villages were combined, the proportion of vectors and potential vectors collected outdoors was significantly higher than indoors ($p<0.0001$).

The indoor vector density of all sites combined was low (0 to 0.3 vector per room per day) at the baseline. Indoor resting densities of *An. gambiae* s.l. and other malaria vectors collected during this entomological monitoring period were very low; thus, the resting habit and impact of IRS on indoor resting density could not be confirmed using this indicator. In most sites, the indoor resting density was zero or close to zero.

A total of 842 mosquitoes were collected from eleven sites in the South East, East and South West of Madagascar resting outdoors in natural and pit shelters using aspirators including, 216 (25.6%) *Anopheles gambiae* s.l. A total of 41 (4.9%) *Anopheles funestus* were also collected at eight sites: Vohitrambato, Vavatenina,

[12] 2018 PMI VectorLink Madagascar Final Entomological Report

[13] 2018 PMI VectorLink Madagascar Final Entomological Report

Manambotra Sud, Lopary, Lanivo, Tsaravary, Mahatsinjo and Ampasimpotsy; 31 (3.7%) *An. mascarensis* were collected from three sites: Vohitrambato, Vavatenina and Ampasimpotsy; 139 (16.5%) *An. coustani* were collected from eight sites; Vohitrambato, Vavatenina, Manambotra Sud, Lopary, Lanivo, Tsaravary, Mahatsinjo and Ampasimpotsy.

6.6.3. Residual Efficacy

The residual efficacy of the pesticide being used for IRS is crucial to evaluating the overall effectiveness of IRS. The wall surface to which the pesticide is applied is a factor affecting residual efficacy, and must be taken into account. It is important that bioassays on various wall surfaces 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 on a given sprayed surface.

In Madagascar, the cone bioassay on sprayed surfaces of 2018 IRS campaign results indicated good spray quality in the East Coast, South East and South West with 100% mortality recorded for all the structures bio assayed at T0 and T1.

At the East Coast sites (Ambodifaho, Brickaville; Vohitrambato, Toamasina II; Mahambo, Fenerive Est) and the South East sites (Manambotra Sud, Farafangana; Lanivo/Anosy, Vohipeno, Ambohimiarina II, Mananjary), most houses have walls made out of wood or falafa (branches of traveler's palm), while houses in the South West are made out of mud or wood.

6.6.4. Pesticide Quality

A fourth major factor affecting the effectiveness of the pesticides is their quality (specification). 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 will be taken prior to shipment to Madagascar and analyzed for the concentration of the active ingredient. In all PMI VectorLink warehouses the temperature is monitored and controlled as much as possible to avoid temperatures that could alter the chemistry or the characteristics of the pesticide.

6.7. Compatibility of the Proposed Pesticide with Target and Non-Target Ecosystems

The pesticides are compatible with the target environment (walls, ceilings, eaves) in that they dry on these surfaces, and are not released to receptors or the general environment to any great extent. The dried pesticide remains on the sprayed surfaces, and performs as designed, killing vector mosquitoes that rest on them, and the exposure to non-target organisms and ecosystems is very limited.

The WHO PQ recommended pesticides are incompatible with the non-target ecosystems (humans, animals, and the environment), in that, if released to the environment in large quantities, they would have negative effects on land and water based flora and fauna. However, the IRS implementation process is designed to ensure that to the maximum extent possible, pesticides are deliberately and carefully applied to the inside walls and ceilings of dwellings, and do not come in contact with humans, animals, or the environment. IRS implementation is also planned to minimize and responsibly manage liquid wastes through the reuse of leftover pesticides, the triple rinsing of equipment, and the daily washing of PPE to remove trace pesticide. Wherever possible, recycling is incorporated into the waste management plan, particularly in the case of plastic bottles used for pesticide containers. Where it is not feasible to recycle materials, they are washed thoroughly and either given away or disposed of in a landfill, or contaminated solid wastes are incinerated in an approved incinerator that will destroy the pesticide and prevent environmental contamination (see Section 6.1.11). The Environmental Mitigation and Monitoring Plan, in Annex A, details the measures that have been and will be enacted to prevent contamination of ecosystems. In addition, there are solid and liquid waste management plans contained in the Safer Use Action Plan of this SEA (Chapter 6).

6.8. THE CONDITIONS FOR PESTICIDE USE

Chapter 3 of this document provides a detailed account of the environmental conditions in Madagascar under which the pesticide is to be used. IRS is scheduled to be performed prior to the rainy season in each location to maximize the effectiveness of IRS, and to avoid logistical complications from the degradation of transportation infrastructure due to flooding and washout.

During IRS, particular attention will be paid to any sensitive areas identified in Chapter 4, including water bodies, schools, hospitals, any area where organic farming is practiced or where bee-keeping or natural bee habitats are established, threatened and endangered species 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 the IP will train sprayers 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 disqualified if unfit. Alternatively, if drift is caused by excessive wind (especially from spraying eaves outdoors) operators must wait until wind conditions subside. The IP will consult with the other in-country organizations to implement entomological monitoring activities 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 stricter, 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

In Madagascar, as in many countries, a full range of malaria control methods are employed, and in some circumstances one method may be favored over another. However, PMI has determined that IRS is part of the overall effort and will be used to decrease malaria morbidity and mortality in Madagascar and in many other countries.

This IRS program is limited to using those pesticides that are on the WHO PQ list of recommended pesticides. WHO currently recommends 17 formulations from five chemical classes for IRS, each with a specific dosage regime, duration of effectiveness, and safety rating.[14,15,16] Each of these agents has been evaluated for effectiveness within the program, and continuing monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign. One goal of this SEA is to broaden the options for pesticide use to six recommended pesticide classes (including chlorfenapyr in the pyrrole class), to combat periodic resistance development.

Nonchemical means of malaria vector control are examined and discussed briefly under Section 6.3, Integrated Pesticide/Vector Management (IPM/IVM), but are generally not effective on a large scale for malaria vector control. For example, while elimination of standing water breeding habitats is a logical and sensible concept, the malaria mosquitoes only need the smallest of aquatic habitats to successfully reproduce, and it is nearly impossible to eliminate all of these minute breeding habitats (e.g., hoof prints or tire ruts).

[14] Najera JA, Zaim M (2002). Malaria vector control – Decision-making criteria and procedures for judicious use of insecticides. WHO, Geneva, WHO/CDS/ WHOPES PQ/2002.5. (Document available at: www.who.int/ctd/WHOPES PQ/docs/JudiciousUseRev.pdf)

[15] Chlorfenapyr is currently under consideration to be included. The 17th WHOPES PQ Working Group (2014) recommended that, considering the potential efficacy of chlorfenapyr to kill pyrethroid-resistant *Anopheles,* further evidence be gathered in Phase II to assess the efficacy of indoor residual application of chlorfenapyr 240 SC against malaria vectors, following the WHO guidelines for IRS.

[16] http://www.who.int/pq-vector-control/prequalified-lists/en/

6.10. MADAGASCAR'S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE

In Madagascar, there is no competent authority for *registration* of insecticides for public health use, but all WHO PQ insecticides are allowed for use in public health.

6.10.1. RELEVANT INSTITUTIONS

The institutional framework for environment has evolved over the years and is now relatively complex. The first higher environmental body to be created was the National Council for Nature established in 1984. Upon launching the NEAP, a new National Environment Office (ONE) was created, initially attached to the Prime Minister's Office with the mandate to coordinate implementation of NEAP. Subsequently a Ministry for Environment was created, which became the overarching authority on environmental affairs to which ONE became attached.

Many NGOs are very active in Madagascar, and have achieved quasi-regulatory status in environmental management, monitoring, and control. For example, the WWF has invested heavily in Madagascar, and has been granted management responsibility for many protected areas within the PMI operating areas. Because of the well-recognized uniqueness of the Madagascar environment and its endemic biodiversity, the activity of international NGOs, and the resultant visibility on the international stage, Madagascar has a greater than average ability to control the distribution, storage, use, and disposal of pesticides to be used for IRS.

6.10.2. LAWS AND REGULATIONS

Loi n°2015-003 portant Charte de l'Environnement Malagasy actualisée: The purpose of the law is to update the Malagasy Environment Charter to reaffirm the commitments made under the principles set out in the Rio Declaration on the Environment and development. The Malagasy Environment Charter must translate these principles by specifying the rights and duties of each level in environment. Any provisions contrary to this law are repealed, in particular the laws n ° 90-033 of December 21st, 1990, n ° 97-012 of June 6th, 1997 and n ° 2004-015 of August 19th, 2004.

To determine the status of the project regarding this regulation, the VectorLink project should conduct a screening. The result of this screening will be used by the Office National de l'Environnement (ONE) to determinate the specific study that the project should complete to obtain an environmental agreement.

Arrêté 4355/97: Définition et délimitation des zones sensibles. This regulation states that all of Madagascar's fragile areas need to be considered in any Environmental Impact Assessment.

Décret MECIE 99-954 du 15/12/99 – modified by Décret 2004-167 du 03/02/04 The MECIE Decree – the compatibility of investments with the environment 99-954 du 15 Décembre 1999 – asked public and private investors to conduct environmental impact studies whenever investments are apt to alter the environment. The new law – February 2004 – helped to clarify the types and procedures of Environmental Impact Assessment (EIA or PREE) depending on the size and the location of the activities – whether it was in a fragile zone or not.

Pest control products act: Malagasy pesticide regulations (Arrêté nº 7452-92 règlementant le stockage et le reconditionnement des produits agropharmaceutiques) provide the guidelines and measures for management of pesticides including storage, transport, usage etc. These regulations will be complied with in the implementation of the IRS program. Thus, IRS must fulfill the requirement for ensuring that all investments are subjected to EIA as represented by this SEA.

Other key laws in the environmental sphere include wildlife laws under the forestry legislation (e.g., Ordinance 60-126) and dependent regulations (notably Decree 88-243 that lists protected species), the law on transfer of management of natural resources to local communities known as GELOSE (Law 96- 025) and the decree

permitting relative securitization of land subject to GELOSE contracts (Decree 98-610). There is also a new law on industrial pollution. A draft consolidating law on protected areas (known as COAP) has been approved by the National Assembly and the Senate and is now only awaiting the signature of the president to allow its promulgation. The current political situation in Madagascar has so far inhibited this happening.

Madagascar has ratified most of the major international environmental conventions including the Algiers Convention on the Conservation of Nature and Natural resources (Law 70-004), the Convention on Biological Diversity (Law 95-013), the International Convention on Trade in Endangered Species (CITES) (Law 75-014), the Ramsar Convention on Wetlands of International Importance (Law 98-004), the World Heritage Convention (ratified 9/12/82), the UN Convention on the Law of the Sea (ratified in October 2000) and the Climate Change Convention (Law 98-020). Of particular note is that Madagascar's protected areas system is currently based on the direct application of the Algiers Convention of 1968.

6.10.3. Strength and Ability of Enforcement

In Madagascar, the State has the power to attribute the responsibility and the management authority to the institutions that are closest to the natural resources in question, if this last request it or agree to assume these responsibilities.

The State must share equitably the costs and benefits of environmental management and ensure a system of recourse in case of conflict or non-respect of the principles invoked in this Charter.

In Madagascar sanction is applicable for any natural or legal person carrying on activities that cause adverse effects on the environment without prejudice to any criminal proceedings that may arise. The culprit is subject to:

- Either to countervailing obligations that will be fixed by regulation; or,
- The payment of penalties to the State which will be fixed by regulatory agencies.

Enforcement in Madagascar is a responsibility primarily shared by the gendarmerie and the police. The environmental police are empowered by territorially competent authorities to ensure public tranquility, safety and security without prejudice.

There are experienced staff members in the ONE that can be involved in activities such as training, and arranging meetings when needed with local DREDD (Direction Regionale de l'Environnement et du developpement Durable) or CIREED (Circonscriptions). .

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. PMI has developed guidelines for IRS operations ("Best Management Practices (BMP) for Indoor Residual Spraying in Vector Control Interventions," updated 2015), and provides a training manual, the Spray Operator Pocket Guide (Were, 2014). Other resources include the *Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning,*[17] USAID PMI's IVM PEA (USAID, 2017 Update), as well as this SEA, all of which provide precautions and recommendations on many aspects of IRS operations. The IRS BMP manual and the PMI IVM PEA requirements are the primary references and have precedence, but the other documents may be used as a reference. It is not incumbent upon the IP to comply with non-PMI documentation except where required by law. However, PMI/USAID requirements are usually stricter than others, so there should not be a conflict.

[17] WHO-UNEP Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning: A Resource Tool. World Health Organization, Geneva. 332 Pages. Document also accessible at: http://www.who.int/WHOPES PQ/recommendations/IPCSPesticide_ok.pdf

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Madagascar. The IP will continue to provide technical support for environmental compliance, with a medium-term goal of building national capacity to progressively transfer responsibilities. Preparations will include the following:

- A training of trainers program, in which potential supervisors,[18] storekeepers, and team leaders are trained on all aspects of IRS operation. Areas of training will include planning of IRS, household preparations, recordkeeping, community mobilization, rational/judicious use of insecticides including sprayer and PPE cleaning, personnel management, and environmental aspects of IRS – including geographical reconnaissance, and data recording and analysis.
- The training of temporary workers recruited from local areas and trained as spray team members (operators, team leaders, and wash persons). New operators will receive five to seven days of training prior to the spray operations.

More information on the training that will be provided is in Section 6, the Safer Use Action Plan.

6.12. The Provisions Made for Monitoring the Use and Effectiveness of the Pesticide

Entomological monitoring is firmly established in the PMI Madagascar Work Plan, and is used for insecticide decision-making, as well as monitoring the effectiveness of applied insecticides. The elements of this monitoring have been laid out in previous sections.

Two kinds of measurements are needed to provide a complete understanding of the effectiveness of pesticide that is being used for IRS. Direct methods measure the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors, and involve entomological evaluations of pesticide-contact bioassays and related pesticide resistance methodologies as recommended by WHO. The second means of measurement relates to the primary goal of reducing the local disease burden. These efforts require specialized entomological and epidemiological skills and the assessment of the impact of vector control operations, and possibly the assessment 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, ceiling) composition. The tests for insecticide efficacy are detailed in section 5.6.

Pesticide manufacturers are well aware that duration of effectiveness is important, and in some cases they are reworking their formulations to provide greater longevity. This is the case for pirimiphos-methyl (organophosphate), which has been formulated as a capsule suspension (CS) that may extend the effectiveness of the application out to six months. Because of the length of the malaria season in Madagascar, this characteristic may be critical to the success of IRS, and this insecticide will be used in 2019 along with the clothianidin and chlothianidin/deltamethrin combination insecticides.

[18] These are usually health-related government staff within the targeted district (health assistants/educators/ inspectors, nursing assistants, and community development assistants).

7. SAFER USE ACTION PLAN

This section outlines the safer use action plan proposed for the potential adverse impacts outlined in Section 6. The primary mitigation measures include delivery of a mix of IEC approaches targeting the residents and spray operators and all IRS personnel, training of spray operators and strengthening supervision and monitoring, and provision of appropriate PPE and facilities for the storage and disposal of pesticides and contaminated waste. The mitigation measures, along with monitoring and reporting information, are compiled in the EMMP found in Annex A.

7.1. IMPLEMENTATION CONDITIONS

During implementation, PMI/Madagascar and its PMI IRS IPs will adhere to the conditions detailed in this Safer Use Action Plan, and in the EMMP, Annex A of this report.

7.1.1. QUANTIFICATION OF PESTICIDE REQUIREMENTS

The PMI IRS IP will conduct an annual logistics assessment for all targeted districts for planning and procurement of the correct quantity of materials, including insecticides. 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.

7.1.2. 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, and at the same time expose the residents and spray operators to hazards related to altered toxicological characteristics.

The PMI program will procure the insecticide from a reputable supplier. Pesticide batches will be analyzed for the concentration of the active ingredient prior to shipment to Madagascar. Additional sampling and testing may be performed upon arrival. Delivery of all insecticide to the central warehouse will be supervised by PMI before the insecticide is dispatched to the districts where spray operations will be concentrated.

7.1.3. PESTICIDE TRANSPORT

After the receipt of insecticide at the central warehouse, insecticides are transported to the district warehouses by road, and in some areas, over water in boats. During transportation, there is a risk of vehicle accidents and consequent insecticide spillage. It is essential that the vehicle type and speed of transport be matched to the conditions; drivers must take no chances.

A lockable box truck is the expected vehicle to transport insecticides over land from central to district stores. If box trucks are not available, Chief of Party or ECO will notify the VectorLink Technical Project Manager and the Director of Environmental Compliance to receive instructions for an alternative security mechanism. All vehicles must be in good condition and pass the Pre-Contract Vehicle Inspection performed by the Environmental Compliance Officer (ECO) or a qualified designate, using a smart phone.

Prior to long-distance transport of the insecticide from the customs warehouse or VectorLink Madagascar central storage facility, drivers will be trained on general issues surrounding the insecticide and how to handle emergency situations such as accidents or spillage. Training for long-distance transport will include the following information:

- Purpose of the insecticide (indoor use for malaria protection, not for agricultural or any other outdoor use)
- Toxicity of the insecticide
- Security issues, including implications of unauthorized access to or use of the insecticide
- Hazardous places along the routes to be taken, and mitigation measures
- Steps to take in case of an accident, spill, or emergency (according to BMP standards)
- Combustibility, and toxicity of the combustion byproducts of insecticide

Drivers hired for intra-district transport of insecticide and spray team members during the spray campaign will receive training in:

- Operator transportation best practices and vehicle requirements from PMI IRS BMP #2, Worker and Resident Health and Safety
- Health and safety as provided to spray operators, with the exception of sprayer operation and spray practice
- Handling an accident, spill, or emergency according to BMP standards
- Handling vehicle contamination
- Vehicle decontamination procedures

Figure 3 below provides a list of eight key responses to mitigate the impact of an insecticide spill.

Figure *3*: Emergency Response to an Insecticide Spill in a vehicle

IN CASE OF INSECTICIDE SPILLS

1. Control, contain, and clean up the spill.
2. Don protective clothing prior to attempting to clean the spills.
3. People must 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.
4. It is imperative to avoid fire as a result of the accident, and a fire extinguisher should be deployed just in case. The engine must be shut off and smoking in the area strictly prohibited.
5. Onlookers and bystanders must be kept away from the accident site.
6. If the crew has come in contact with the pesticides, they must remove contaminated clothing immediately and wash the pesticide off their skin.
7. For major spills send for help immediately; Drivers must have a charged cell phone and an emergency number for use in such cases.
8. Vehicles that are used for transporting large quantities of pesticides are required to be equipped with a bucket of sand, sawdust or soil, a shovel, and fire extinguisher.

Because vehicles used for insecticide transportation can be used for the transport of other goods, it is important to ensure that vehicles are decontaminated after use. 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 and water.

If pesticide is transported over water, BMP #10, Water Transport (PMI IRS BMP Manual, 2015) must be followed in every detail.

7.1.4. Qualification of Warehouses (Storage Facilities)

IRS pesticides can cause adverse impacts to human health, animals, and the natural environment if not properly stored according to PMI BMPs. Before insecticides are procured or transported to the spray areas, suitable warehouse(s) must be assessed to ensure that they can meet BMP standards. During the geographical reconnaissance and logistics assessments, the need for new district warehouses or rehabilitation of previously used district warehouses to meet PMI IRS BMP standards for pesticide storage will be assessed. The standards include:

- Located at least 30 meters from flood plains, wetlands and water bodies, markets, schools, dwellings, beehives, and protected areas. Warehouses may not be located in the buffer zones of protected areas, or in schools while in session.
- Spacious enough to store insecticides in bulk and to store other IRS commodities separately
- Providing a separate space for the storekeeper's office
- Well ventilated and allowing for air circulation
- Built of concrete or other solid material
- Impervious flooring, or floor must be completely covered by a leak-free tarpaulin

- Watertight roofing
- Barred and screened windows
- Preferably two exits from the pesticide storage area for emergency purposes
- A fire extinguisher

In addition to the above, all facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of Madagascar pesticide regulations. During the logistical needs assessment, the PMI IRS IP will identify warehouses at the district level that can meet these requirements. PMI cannot provide funds for the construction of new buildings, but can assist in the modification or renovation of existing facilities. In Madagascar, IRS is implemented in partnership with the Ministry of Health/NMCP; therefore, some warehouses are located on District Medical Office property for logistic and security purposes. There is also the possibility of using the warehouses of departmental services of the Ministry of Agriculture. This would meet the eligibility criteria of the project requirements.

7.1.5. Qualification of Liquid Waste Disposal Facilities (Wash Areas, Soak Pits, and Evaporation Tanks)

Pyrethroids, organophosphates, neonicotinoids, and carbamates degrade quickly when exposed to environmental action such as photolysis, hydrolysis, and bacterial action. If wash areas and soak pits are properly constructed in appropriate locations and used according to BMPs, liquid pesticide waste will be captured in the charcoal layer of the soak pit and held until it breaks down by these natural processes.

Site considerations for locating IRS cleaning and waste facilities (progressive rinse, wash areas, soak pits, and tanks) 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 are not always appropriate for siting a wash area, so it may need to be placed some distance away. Due to access limitations and distance to some spray sites, it may be more feasible to locate a small wash 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 bodies, flood plains, habitat, schools and other public buildings, areas protected by regulations, mining extraction sites, and areas of high groundwater. 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 be constructed to slope gently toward the soak pit or toward the collection point that is piped to the soak pit/evaporation tank.

Although the soak pit captures the majority of pesticide from wash waters, small amounts may pass through and enter the soil below. Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or microbiological 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 to capture and degrade trace amounts of pesticide. Hard-packed clay or rocky soils are not appropriate.

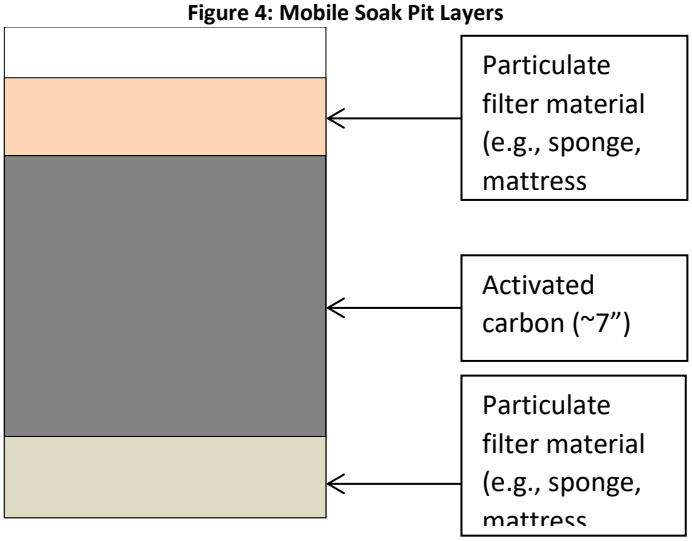
Pesticides may move in water runoff as compounds dissolve in water or attach to soil particles. Facilities should be located on high, level ground to minimize exposure to runoff. Avoid steep slopes or natural runoff flow lines. Where necessary, curbs or berms will be constructed around wash areas to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

MOBILE SOAK PIT (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 MSP filter is a 20-25 L bucket with highly adsorbent activated carbon that removes pesticide contamination from the wash water, so that the water that exits to the ground is purified. For more information on the mobile soak pit, please see the PMI BMP manual.[19]

Figure 4: Mobile Soak Pit Layers



Designed and drawn by Peter Chandonait, Abt Associates, Inc.

7.1.6. WAREHOUSE & STORAGE RISK MANAGEMENT

In order to mitigate risks associated with pesticide storage, the following will serve as warehouse/storage best management practices:

- A trained storekeeper will manage each facility and will wear gloves, a mask, overalls, and boots when in the pesticide area of storage.
- No smoking or eating will be allowed within 30 meters of the pesticide storeroom.
- Pesticide storage facilities must have thermometers installed for daily temperature recording.
- Basins, soap and clean water will be available at all times in all the facilities.
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed.
- A fire extinguisher will be available in the storage facilities and all site workers will be trained on how to use this device.
- Warning notices will be placed outside of the store with a skull and crossbones pictogram and warnings in the local language.
- Insecticides must be lifted off of the floor via pallets or shelves, and separated from the walls of the storeroom by 9-12 inches.
- First-aid kits must be fully stocked and available in all the central warehouses and secondary

[19] Chandonait, Peter. February 2015. *President's Malaria Initiative BMP Manual Best Management Practices (BMP) For Indoor Residual Spraying (IRS) In Vector Control Interventions.* Bethesda, MD. PMI | Africa IRS (AIRS) Project, Abt Associates.

stores. Security and inventory management of first aid supplies is mandatory.

ACCIDENTAL WAREHOUSE FIRES

Inhalation of toxic fumes in the event of a storehouse fire is a major risk of IRS. The risk can be minimized, however, by following BMPs for storage, including prohibiting lighted materials in or near the warehouse or in the vicinity of pesticides during transport to/from vehicles, providing fire extinguishers, and proper ventilation of storerooms.

7.1.7. FETAL EXPOSURE (PREGNANCY TESTING)

All female candidates for spray teams will be tested for pregnancy before being recruited into the spray operations, and every 30 days until operations end. Provided their work history has been acceptable, females who have been hired and later found to be pregnant will be reassigned 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 or washing contaminated items.

7.1.8. SPRAY OPERATOR EXPOSURE

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps, including hands-on exercises prior to the beginning of the spraying campaign. They will also be trained 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 will be conducted in accordance with the IRS Training Guide for Spray Operations (USAID, 2009) and the 2015 IRS BMP manual. Potential spray operators must also pass written and practical tests at the end of training.

Training for monitoring spray operators for symptoms of pesticide exposure will be mandatory for team leaders and supervisors, as well as for storekeepers and other senior personnel. Any case of an operator or beneficiary displaying symptoms of exposure will require the immediate completion of a standard Incident Report Form by the district coordinator, who will forward the report to the IP's headquarters within 24 hours. The incident report must be received from the IP's Technical Project Manager by PMI COR within 48 hours.

For malathion and fenitrothion organophosphates, it may be necessary to monitor the level of acetyl cholinesterase in any worker who may have been exposed to contamination. Occupational exposures to organophosphate insecticides are measurable using blood cholinesterase testing and urinary excretion of chemical biomarkers. PMI has evaluated various approaches for monitoring sprayer exposure to organophosphates, and has determined that biomonitoring is not required when using pirimiphos-methyl. Moreover, the WHO PQ Working Group recommendations stated that "provided that operational guidelines are followed, routine cholinesterase monitoring of spray men during IRS programs is not required" for Actellic CS.

7.1.9. BENEFICIARY EXPOSURE

Residential exposure will also be monitored. During the IEC campaign, residents are made aware of the steps to take if exposed, and, especially if acute symptoms are encountered, the advice is to report to the nearest health facility. Thus, reported cases at health facilities or by IEC mobilizers will serve as the principal monitoring strategy for beneficiary exposure incidents.

NMCP, DMOs, and the PMI IRS IP and other partners will work with relevant institutions at all levels to carry out an IEC/BCC campaign to sensitize residents to IRS activities, in accordance with WHO guidelines and also the Madagascar National Malaria Strategic Plan 2014-2020 and PMI Malaria Operational Plans. The IEC campaign (as well as IRS project leaders and Ministry of Health/NMCP Officers) 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 cover with impermeable material.

- Residents must stay at least 10 meters from the home during spraying, and for two hours after spraying.
- Move and keep all animals at least 10 meters from 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 before allowing re-entry by children and animals.
- Do not relater or paint over the sprayed walls after spraying.
- Keep using bed nets for additional 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, or if symptoms of other types of exposure persist, contact program staff or go to nearest health facility that has the appropriate medical intervention.

If spraying during the rainy season, the teams should adhere to the following Contingency Plan, which will minimize exposure of household effects**.**

- Each spray operator must be given adequate covering material (3m by 3m minimum), which should then be used to cover household effects that have been moved to the center of the room (rather than outdoors) because it has started to rain. More than one sheet may be required, depending on the size of structures and the amount of belongings.
- Household effects can also be moved into structures that are not targeted to be sprayed, e.g., an isolated kitchen or domestic animal shelter.
- Household effects can alternatively be moved to one room that will not be sprayed on that particular day, but on 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 middle of spraying, stop the spraying activities; resume when the rain stops and the skies clear.

7.1.10. Pesticide Exposure and Treatment

All spray operators, team leaders, and supervisors will receive detailed training on the emergency steps to take if accidental exposure to the chemical occurs, including ingestion, inhalation, or eye or dermal contact with the chemical. This training will be conducted by the district and sector coordinators, and will include drills to test knowledge of the operators. However, most interventions for acute exposure will have to be provided by medical professionals at the nearest health clinic, so transporting the exposed person to the health clinic will be the priority.

PMI IP will confirm that all the health facilities around the spray sites have in their store the recommended treatment drugs, and that all the staff responsible for administering emergency treatment for pesticide exposure receive appropriate training. Annex F provides additional information on symptoms and treatment protocols.

7.1.11. SOLID AND LIQUID CONTAMINATED WASTE MANAGEMENT

Non-contaminated wastes, or those that can be cleaned thoroughly with soap and water, will be recycled whenever possible, or disposed of in a municipal landfill if there is no appropriate recycling outlet.

Liquid contaminated wastes will be disposed of on a daily basis in soak pits that are carefully sited and designed according to the criteria in this Safer Use Action Plan and the PMI BMP manual. The soak pit is designed so that pesticides are adsorbed by the charcoal layer and held until environmental processes result in the degradation of the pesticide. Thus, there should be no contaminated liquid waste to deal with at the end of the spray season.

Contaminated solid wastes are incinerated in incinerators that are capable of destroying the pesticide and preventing environmental contamination.

Incinerators recommended for disposal of contaminated wastes fall into two categories:

- Basel Convention technical standards, for all insecticides that do not contain greater than 1% chlorine
- WHO/FAO standards, which apply if using DDT or insecticides that contain >1% chlorine

For wastes containing less than 1% chlorine:

- The recommended combustion temperature is >850 °C.
- An after-burner is required, with a residence time of at least two seconds.
- The incinerator must 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 Madagascar, as solid wastes are incinerated in a PMI-owned incinerator, ash and slag will be incorporated into cement blocks and buried.

For wastes containing greater than 1% chlorine:

- The recommended combustion temperature is between 1100 and 1300 °C.
- An after-burner is required, with a residence time of at least two seconds.
- A quench rinse that causes a rapid temperature drop to below 250 °C is needed for the gas stream.
- The incinerator must 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 Madagascar, as solid wastes are not incinerated in a PMI-owned incinerator and the IP does not have control over the ash and slag, VectorLink can only recommend this disposition.

Incineration is not recommended for polyvinyl chloride or other chlorinated wastes such as gloves and boots. Gloves and boots no longer usable for IRS can be easily decontaminated with soap and water and then 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 contaminated waste. In many cases uncontaminated boxes can be recycled, or can also be disposed of as normal

non-hazardous wastes. 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 Madagascar, the management of contaminated wastes from IRS activities will take place ADONIS. ADONIS is the main agreed company which work with the IRS project since past years.

The EMMP in Annex A gives further details on the steps and measures that will be taken to prevent negative impacts on the non-target ecosystems from liquid and solid IRS waste materials and disposal practices.

Annex A: Environmental Mitigation and Monitoring Plan

PMI VECTORLINK PROJECT (AID-OAA-TO-17-00027)

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
1. Education, Technical Assistance, Training	Activities involving studies, education, technical assistance, training, or information transfer, except to the extent they directly affect the environment (such as construction of facilities), are recommended for categorical exclusion.	N/A – Categorical Exclusion	N/A	N/A	N/A	N/A
2. Research and Development	Entomological surveillance and vector control research use laboratory equipment, chemical reagents,	• Implement laboratory environmental, health, and safety (EHS) manuals with standard operating procedures (SOPs), or use existing SOPs, for laboratory operations in accordance with country-	Laboratory personnel within the respective country, with oversight provided by	• EHS manual/Standard operating procedures (SOPs)implemented per PMI and	• Review of EHS manual/SOPs to ensure it is appropriate, and complies with PMI, WHO and country-	• Routine site visits, as needed, to ensure accordance with operating plan

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	insecticides, and entomological surveillance supplies that have the potential to cause adverse health and environmental impacts if not properly managed. These materials require special care and management to minimize their expiration and/or damage.	specific compliance mechanisms. • Implement SOPs for the safe storage, transport, and use of equipment, chemical reagents, insecticides, and supplies in conformance with international best practices (e.g., WHO, FAO) and host country requirements. • Provide training to workers on the approved SOPs or Waste Management Plan (WMP) developed for properly handling and disposing of wastes.	Abt Associates technical experts.	country-specific requirements • Training of staff in activities related to the laboratory EHS manual/SOPs	specific recommendations for safety, use of personal protective equipment(if needed), spill prevention, and training. • Review training materials and logs to verify trainings were conducted • Confirm during routine visits that SOPs are being effectively implemented and that workers are reporting EHS incidents • Include date of visits, findings and any non-compliance issues in the annual EMMR	

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
					• Include photographs from site visits	
3. Public Health Commodities	N/A	N/A	N/A	N/A	N/A	N/A
4. Small-Scale Construction	• Lack of necessary permits and assessments in place in advance • Improper siting or construction techniques causing: - Deterioration of human and social environments: - Erosion or sedimentation - Creation of disease vector habitat • Use of construction equipment can cause injuries to workers and bystanders. • Construction activities during	• Obtain all needed authorizations prior to construction: permits, environmental and social impact assessments, etc. • Retain competent, licensed professionals to design and supervise construction • Establish health, safety and environmental obligations in all contracts. • Complete a site emergency action plan • Provide safety training to all workers using construction equipment • Identify closest health care facility to handle injuries • Asbestos, lead based paints and other toxic materials will not be used under any circumstances. If the presence of asbestos is suspected in a facility to be renovated, the facility must be	Abt Associates technical overseers and Environmental Compliance Officers, with assistance from USAID Mission personnel. Contractors	• Permits on file • Construction contracts are in place for engaged professionals and reflect requirements of USAID guidelines for small-scale construction • Waste management plan in place and being followed to identify and characterize all waste streams from the project with the proposed final disposal option • SOPs implemented	• Review all demolition, emergency, safety, waste management, and construction plans and contracts prior to renovations. • Provide continual oversight of operations by regular site inspection visits. Review WMP to ensure it is adequate • Review records to verify trainings/ briefings were conducted	Pre-, mid- and post construction. Inspect construction sites at least weekly

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	renovation of facilities may generate debris and wastes that contain both non-hazardous and hazardous materials that require proper disposal. This includes chemicals, solvents, and any materials containing toxics, such as asbestos, lead-based paint, and formaldehyde. • Exposure to hazardous building materials during renovation activities can result in health impacts to workers. • Waste produced during the construction or	tested before rehabilitation works begins. Should asbestos be present, then the work must be carried out in conformity with host country requirements and with guidance to be provided by the Implementing Partner. All results of the testing for asbestos shall be communicated to the COR • Develop and follow a waste management plan (WMP). Identify authorized recycling or disposal facilities prior to generation of waste. • Minimize the generation of waste by: - Correctly assessing material needs (not over-buying) - Reducing amount of packaging used by suppliers - Reusing material on site, such as use of discarded materials for leveling ground and filling trenches, etc. • Designate secure on-site waste storage facilities • Ensure all workers are trained and dispose of wastes properly.		• Staff briefings on activities related to SOPs		

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	refurbishment work can be harmful to the environment and human health. • Use of environmentally unsustainable construction materials such as wood can lead to environmental degradation • Lack of personal protective equipment may lead to accidents, injuries, or exposure of workers. • Construction activities may produce noise and air pollution • Construction activities can create standing water and breeding habitats for disease	• Complete and track hazardous waste manifests for all shipments • Source all construction material from an ecologically safe provider. • Contractor must provide and all workers must use personal protective equipment (PPE) such as hardhats, footwear, dust mask, safety glasses and reflective vests, as needed. • Ensure first aid and spill clean-up kits are easily available • Contractors must comply with the "Small-Scale Construction" chapter of the USAID Sector Environmental Guidelines (www.usaidgems.org/sectorGuidelines.htm). • Contractor will provide drinking water, latrine and a handwashing station to workers. • Contractors will arrange working hours to minimize disruption to the community. • If needed, construct drainage canals and infiltration pits for				

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	vectors.	management of storm water and prevention of soil erosion. • Post-construction: ensure leftover materials have been properly disposed of.				
5. Small-Scale Water and Sanitation	N/A	N/A	N/A	N/A	N/A	N/A
6. Nutrition	N/A	N/A	N/A	N/A	N/A	N/A
7. Vector Control - IRS	1. Health and environmental impacts may result due to inadequate quality control of insecticides (i.e. procuring non-approved insecticides, improper storage, or poor inventory management).	• Insecticide selection for any USAID-supported malaria program is subject to the criteria listed in the USAID Programmatic Environmental Assessment, country SEAs, and host country requirements. • Procurement and inventory logs must be maintained. • Ensure storage facility and personal protective equipment (PPE) are appropriate for the active ingredient used and in accordance with approved SOPs. • Distribute insecticides to facilities that can manage such commodities safely in storage, use, and disposal (i.e. in a	District Coordinator (DC), Operations Manager (OM), Abt Environmental Compliance Officer (ECO), Abt Vector Control Manager (VCM), Storekeepers (These positions are representative of the responsibilities	• PMI BMPs reviewed and implemented • Procurement and inventory logs maintained • Proper PPE used by workers, if needed. • Operations facilities are sited appropriately • All insecticide management records are reviewed and maintained	• Inspection of facilities, conditions, PPE use, and logs • Review of waste management records and storekeeper performance checklists. • Verify that inspection reports and storage records are properly maintained and document verification in the annual	• Daily monitoring by storekeeper or site supervisor • Weekly monitoring by DC • Monthly review of procurement logs and inventories by OM

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		manner generally equivalent to Implementing Partner's own SOPs/WMP)	required, but may not reflect the exact job title.)		EMMR. • ECO performs mid-application inspections. Verify that inspection reports are properly maintained and document verification in the annual EMMR	
	2. Occupational risks for workers involved in IRS campaigns.	• Inspect and certify vehicles used for insecticide or team transport prior to contract. • Train drivers • Ensure availability of cell phone, personal protective equipment (PPE) and spill kits during insecticide transportation. • Initial and 30-day pregnancy testing for female candidates for jobs with potential insecticide contact. • Health test all spray team members for duty fitness.	DC, OM, ECO, Chief of Party, and Abt Associates technical experts within the respective country	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. Records are kept of pregnancy testing for all	a-c. ECO inspection of vehicles in the field. d-e. ECO inspection of health records at operations sites. f-h. ECO performs pre-application inspections of inventories and training records, and mid-application inspections of PPE use and operator	a-c. 2 inspections per week. d-e. One inspection per campaign, additional inspection if new hires or more than 30 application days. f-h. ECO pre-application inspections 2

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		• Procure, distribute, and train all workers with potential insecticide contact on the use of PPE. • Train operators on mixing insecticides and the proper use and maintenance of application equipment. • Provide adequate facilities and supplies for end-of-day cleanup. • Enforce application and clean-up procedures.		female team members. e. Records are kept of medical exam results for all team members. f. Operators wear complete PPE during application and clean-up, according to SOP requirements. g. Operators mix insecticide properly, and equipment 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.	performance. i. Monitoring of on-line database for submission of inspection reports.	per campaign, ECO mid-application inspections 5 times per week. i. Weekly
	3. Health and safety risks for residents of treated	a. Implement Information, Education and Communication (IEC) campaigns to inform	IEC officers, OM, ECO, host country	a. Review IEC materials and records and	a. Review IEC materials and records to verify	a. Review IEC materials once per campaign

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	houses (e.g., risks from skin contact and/or ingestion of insecticides)	homeowners of responsibilities and precautions, including washing itchy skin and going to health clinic if symptoms develop and do not subside b. Ensure health facility staff are aware of insecticide poisoning management	Ministry of Health/Environment officials.	execute pre-application IEC campaigns	IEC pre-application campaigns were conducted and homeowners were informed of responsibilities and precautions	
	4. Nearby residents may be exposed to insecticides if insecticides are not securely stored to prevent theft and misuse incidents, including the illegal resale of insecticides.	• Storage facilities and transportation vehicles must be physically secured to prevent theft. • Maintain records of all insecticide receipts, issuance, and return of empty containers. • Conduct analysis comparing number of houses treated vs. number of containers used. • Examine houses treated to confirm application • Perform physical inventory counts during the application season.	Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO	• Storage facilities and transportation vehicles are secured. • All insecticide management records are reconciled.	• Inspection of storage facilities and transportation vehicles. • Inspection of insecticide management records. Storekeeper performance checklists. • ECO mid-campaign inspections.	• Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District Coordinator • Examine houses during campaign according to schedule in SOPs. • Physical inventory counts twice per campaign

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
						per store room.
	5. Ecological risk to non-target species and water bodies from use of insecticides	• For shipments of insecticide over water, sachets/ bottles will be packed in 220 liter open top barrels with a water-tight top and a locking ring, or in a similar durable container. Waterproof labeling must be affixed to the barrel, with the identity of the pesticide, number of bottles inside, the weight, the type of hazard posed by the contents, and the personal protective equipment to be worn when handling the barrel. • Train applicators on the SEA operational requirements, SOPs, PMI BMPs, and approved WMP, developed for the safe and effective storage, distribution, application, and disposal of insecticides • Ensure application equipment and PPE are appropriate for the active ingredient used and in accordance with approved	DC, OM, ECO	• Training materials and records • Equipment is maintained and operated to eliminate leaks. • Applicators only mix and apply insecticides according to SOPs	• Review training materials and records to verify trainings were conducted • Conduct inspections during operations. • Verify that inspection and incident reports are properly maintained and document verification in the annual EMMR. Include any issues identified during inspections in the annual EMMR	• Inspect work records once per campaign • Inspections during operations 3 times per week • Review training materials once per campaign

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		SOPs, and maintain equipment to avoid leaks. • Maintain application equipment • No application of insecticides within 30 yards of beekeeping sites				
	6. Environmental risk from disposal of liquid and solid wastes	• Handling, treatment, and disposal of nonhazardous (general waste) and hazardous wastes must be in accordance with the approved WMP/SOPs and the PMI BMPs. The WMP, which outlines SOPs for managing waste processes, must be in accordance with PMI best practices and host country requirements • Choose sites for disposal of liquid wastes, including fixed and mobile soak pit sites according to PMI BMPs • Construct fixed and mobile soak pits with charcoal according to the BMPs to adsorb insecticide from rinse water • Maintain soak pits as necessary during season	DC, OM, ECO	• WMP implemented and disposal sites inspected and certified before campaigns. • Disposal sites near operations sites are appropriate according to PMI BMPs • Soak pits are constructed according to PMI BMPs • Soak pits perform properly throughout the application	• Review WMP/SOPs to ensure it conforms to PMI BMPs and WMP is available on site • Pre-application inspections. Verify that inspection reports are properly maintained and document verification in the annual EMMR. Include any issues identified during inspections in	• Pre-application inspections: once per campaign • Mid- and post-application inspections: twice per campaign • Review of WMP/SOPs during campaign

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		• Monitor waste storage and management during campaign • Monitor disposal procedures post-campaign		season • Wastes are stored and managed according to PMI BMPs • Waste disposal is conducted in accordance with the WMP/SOPs and records maintained	the annual EMMR • Mid- and post-application inspections and monitoring. Verify disposal practices in inspection reports and document in the annual EMMR. Include any issues identified during inspections in the annual EMMR. • Review WMP/SOPs to for effectiveness and maintain on site	
	7. Improper incineration of wastes and disposal of residual ash can pose a threat to air	• Wastes will only be disposed in incinerators that comply with PMI BMPs Collect and maintain treatment and	COR, Abt ECO, Abt Technical Experts	• Incinerator specifications • Maintenance of treatment and	• Review incineration records and document in	• Review incinerator specifications prior to

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	quality, soil, and the water supply and result in environmental and public health hazards.	disposal documents and records on file • Country-level USAID EC documentation must contain guidance on proper disposal of wastes		disposal records • Reg 216 documentation for incinerator procurement and management services reviewed by COR and GH BEO.	the annual EMMR	disposal arrangement • Annual review of disposal records
7. Vector Control - Testing of Insecticide-Treated Nets.	1. Risk of theft from storerooms, followed by unintended use.	1. Store nets only in storerooms secured with sturdy doors, locks, and barred windows.	Environmental Compliance Officer, USAID Mission	1. Storerooms are secure with sturdy doors, locks, and barred windows..	1. Inspection of storeroom for required features	1-2. Once per activity (e.g., campaign) or per fiscal semester.
7. Vector Control - Distribution of Insecticide-treated Nets Applies only in countries where VectorLink distributes ITNs to beneficiaries and is responsible for ITN	1. Misuse of non-expired ITNs (i.e., nets used for non-public health purposes such as fishing)	Where there is evidence of misuse for fishing, assess the extent of misuse and collaborate across sectors (Ministries of Health, Environment, and Agriculture) to develop a sustainable, locally relevant solution	Abt Associates ECO and country senior staff where ITNs are delivered at scale and fishing occurs.	Key messages in place to reinforce appropriate ITN use, particularly in areas where ITNs are delivered at scale and fishing is practiced.	Verification of key messages.	Continuously when personnel are in the field
	2. Reduced efficacy of LLINs due to	Store LLINs in dry, ventilated facilities	ECO, store manager	Confirmed evidence of ITN storage consistent	Visual observation and evidence (photos) of	Continuous observation

Category of Activity from the Prevention of Mosquito-Borne Diseases through Vector Control IDIQ IEE	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures for these activities	Who is responsible for monitoring?	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
transport, storage, distribution, disposal and/or SBC activities.	improper storage			with country-specific and established guidelines	storage capacity, security, conditions	
	3. Pilferage of LLINs and consequential human and environmental exposure	Store in a secure facility to prevent theft or unauthorized access. Post guard or use barred windows as needed	ECO, store manager	Visual and physical evidence of the security of windows and doors	Visual observation and physical testing of the security of windows and doors	Continuous by store manager, bi-annual by ECO
	4. Contamination of edible or potable materials due to contact with ITNs	Do not store LLINs with food, feed, or potable water supplies	Store manager, ECO	Presence or absence of sensitive materials stored with LLINs	Visual observation	Continuous monitoring by store manager, 4 times/yr by ECO
	5. Worker safety (handling LLINs that are not individually packaged)	Provide worker training on the proper handling of LLINs	ECO, store manager	ITN handling knowledge assessed among distribution agents	Interviews with workers	Prior to engaging workers for distribution of nets.
	6. Human and environmental impacts of washing LLINs	Ensure that SBCC materials and outreach activities are coordinated with ITN distribution activities during campaigns, and include guidelines on how to properly wash and maintain LLINs (e.g., discourage disposal of wash water in sensitive ecosystems, discourage washing and rinsing	IEC coordinator, ECO	Key messages developed to reinforce correct ITN wash practices	Review of ITN key messages with campaign/health personnel	Upon distribution of nets, 4 times/yr. by ECO

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		LLINs in water bodies)				
	7. Human and environmental impacts of bags and baling materials used to package LLINs	Ensure that SBCC messages inform campaign distributors and local communities about the potential harm to human health and environment if bags and baling materials are reused; support the development of a communication plan that provides messages on best practices for handling and disposing of bags and baling materials.	IEC coordinator, ECO	Presence or absence of SBC materials on best practices included in MOH communication plans or materials developed with VectorLink support.	Visual observation of MOH plans, materials developed with VectorLink support	Annually.
8. Emergency Response	N/A	N/A	N/A	N/A	N/A	N/A

ANNEX B:
ENVIRONMENTAL MITIGATION AND MONITORING REPORT FORM

Vector Link Madagascar

ENVIRONMENTAL MITIGATION AND MONITORING REPORT (EMMR)

ANNUAL REPORTING FORM

Implementing Organization:

Geographic location of USAID-funded activities:

Period covered by this Reporting Form and Certification:

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
2. Research and Development • Implement laboratory environmental, health, and safety (EHS) manuals with standard operating procedures (SOPs), or use existing SOPs, for laboratory operations in accordance with country-specific compliance mechanisms. • Implement SOPs for the safe storage, transport, and use of equipment, chemical reagents, insecticides, and supplies in conformance with international best practices (e.g., WHO, FAO) and host country requirements. • Provide training to workers on the approved SOPs or Waste Management Plan (WMP) developed for properly handling and disposing of wastes.			
4. Small-Scale Construction • Obtain all needed authorizations prior to construction: permits, environmental and social impact assessments, etc. • Retain competent, licensed professionals to design and supervise construction • Establish health, safety and environmental obligations in all contracts. • Complete a site emergency action plan • Provide safety training to all workers using construction equipment • Identify closest health care facility to handle injuries • Asbestos, lead based paints and other toxic materials will not be used under any			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
circumstances. If the presence of asbestos is suspected in a facility to be renovated, the facility must be tested before rehabilitation works begins. Should asbestos be present, then the work must be carried out in conformity with host country requirements and with guidance to be provided by the Implementing Partner. All results of the testing for asbestos shall be communicated to the COR • Develop and follow a waste management plan (WMP). Identify authorized recycling or disposal facilities prior to generation of waste. • Minimize the generation of waste by: - Correctly assessing material needs (not over-buying) - Reducing amount of packaging used by suppliers - Reusing material on site, such as use of discarded materials for leveling ground and filling trenches, etc. • Designate secure on-site waste storage facilities • Ensure all workers are trained and dispose of wastes properly. • Complete and track hazardous waste manifests for all shipments • Source all construction material from an ecologically safe provider. • Contractor must provide and all workers must use personal protective equipment (PPE) such as hardhats, footwear, dust mask, safety glasses and reflective vests, as needed. • Ensure first aid and spill clean-up kits are easily available • Contractors must comply with the “Small-Scale Construction” chapter of the USAID Sector			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
Environmental Guidelines (www.usaidgems.org/sectorGuidelines.htm). • Contractor will provide drinking water, latrine and a handwashing station to workers. • Contractors will arrange working hours to minimize disruption to the community. • If needed, construct drainage canals and infiltration pits for management of storm water and prevention of soil erosion. • Post-construction: ensure leftover materials have been properly disposed of.			
7a. Indoor Residual Spraying • Insecticide selection for any USAID-supported malaria program is subject to the criteria listed in the USAID Programmatic Environmental Assessment, country SEAs, and host country requirements. • Procurement and inventory logs must be maintained. • Ensure storage facility and personal protective equipment (PPE) are appropriate for the active ingredient used and in accordance with approved SOPs. • Distribute insecticides to facilities that can manage such commodities safely in storage, use, and disposal (i.e. in a manner generally equivalent to Implementing Partner's own SOPs/WMP)			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
• Inspect and certify vehicles used for insecticide or team transport prior to contract. • Train drivers • Ensure availability of cell phone, personal protective equipment (PPE) and spill kits during insecticide transportation. • Initial and 30-day pregnancy testing for female candidates for jobs with potential insecticide contact. • Health test all spray team members for duty fitness. • Procure, distribute, and train all workers with potential insecticide contact on the use of PPE. • Train operators on mixing insecticides and the proper use and maintenance of application equipment. • Provide adequate facilities and supplies for end-of-day cleanup. • Enforce application and clean-up procedures.			
• Implement Information, Education and Communication (IEC) campaigns to inform homeowners of responsibilities and precautions, including washing itchy skin and going to health clinic if symptoms develop and do not subside • Ensure health facility staff are aware of insecticide poisoning management			
• Storage facilities and transportation vehicles must be physically secured to prevent theft. • Maintain records of all insecticide receipts, issuance, and return of empty containers. • Conduct analysis comparing number of houses treated vs. number of containers used. • Examine houses treated to confirm application			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
• Perform physical inventory counts during the application season.			
• For shipments of insecticide over water, sachets/ bottles will be packed in 220 liter open top barrels with a water-tight top and a locking ring, or in a similar durable container. Waterproof labeling must be affixed to the barrel, with the identity of the pesticide, number of bottles inside, the weight, the type of hazard posed by the contents, and the personal protective equipment to be worn when handling the barrel. • Train applicators on the SEA operational requirements, SOPs, PMI BMPs, and approved WMP, developed for the safe and effective storage, distribution, application, and disposal of insecticides • Ensure application equipment and PPE are appropriate for the active ingredient used and in accordance with approved SOPs, and maintain equipment to avoid leaks. • Maintain application equipment • No application of insecticides within 30 yards of beekeeping sites			
• Handling, treatment, and disposal of nonhazardous (general waste) and hazardous wastes must be in accordance with the approved WMP/SOPs and the PMI BMPs. The WMP, which outlines SOPs for managing waste processes, must be in accordance with PMI best practices and host country requirements			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
• Choose sites for disposal of liquid wastes, including fixed and mobile soak pit sites according to PMI BMPs • Construct fixed and mobile soak pits with charcoal according to the BMPs to adsorb insecticide from rinse water • Maintain soak pits as necessary during season • Monitor waste storage and management during campaign • Monitor disposal procedures post-campaign			
• Wastes will only be disposed in incinerators that comply with PMI BMPs Collect and maintain treatment and disposal documents and records on file • Country-level USAID EC documentation must contain guidance on proper disposal of wastes			
7b. Testing of ITNs • Store nets only in storerooms secured with sturdy doors, locks, and barred windows.			
7c. Distribution of ITNs • Where there is evidence of misuse for fishing, assess the extent of misuse and collaborate across sectors (Ministries of Health, Environment, and Agriculture) to develop a sustainable, locally relevant solution			
• Store LLINs in dry, ventilated facilities			
• Store in a secure facility to prevent theft or unauthorized access. Post guard or use barred windows as needed			

List each Mitigation Measure from column 3 in the EMMP (EMMT Part 2 of 3)	Status of Mitigation Measures	List any outstanding issues relating to required conditions	Remarks
• Do not store LLINs with food, feed, or potable water supplies			
• Provide worker training on the proper handling of LLINs			
• Ensure that SBCC materials and outreach activities are coordinated with ITN distribution activities during campaigns, and include guidelines on how to properly wash and maintain LLINs (e.g., discourage disposal of wash water in sensitive ecosystems, discourage washing and rinsing LLINs in water bodies)			
• Ensure that SBCC messages inform campaign distributors and local communities about the potential harm to human health and environment if bags and baling materials are reused; support the development of a communication plan that provides messages on best practices for handling and disposing of bags and baling materials.			

ANNEX C: PUBLIC CONSULTATION & PREPARATION METHODOLOGY

This SEA was prepared by the PMI VectorLink Regional Environmental Compliance Manager, Sana Diop Dieng, under the supervision of Alexis Hardie, PMI VectorLink Environmental Compliance Manager, and Peter Chandonait, PMI VectorLink Director of Environmental Compliance and Safety. A short-term technical assistance trip was made to Madagascar, in order to meet with major stakeholders and gather the information necessary for the SEA preparation. During the first week, the RECM met with the USAID Mission in Madagascar to discuss the purpose of the visit and to receive any relevant guidance with regard to the SEA.

We also visited with the relevant government partners including the NMCP, the National Office of Environment (Office national de l'Environnement) and the Directorate of Plant Protection (Direction de la Protection des Végétaux) to receive their input and feedback about their recent experience with our IRS program, as well as to gather any information about stakeholders' impressions and acceptance of IRS.

The trip was also the occasion to work with the VectorLink Madagascar team on the supervision through mobile phones and environmental compliance work with the team. In the field, the REMC made a visit to Sakara and Tulear, two out of the five previous operating IRS districts of 2019. Those visits consisted of meeting with district health and hospital officials, as well as rural development officers, officials responsible for the South West Region and the national park manager at Sakara. A visit to protected areas was also made as the protected Area Zombitse Vohibasia in Sakara and Saint Augustin in protected Area of Tsinjoriake.

Additional visits for the week included an inspection of the central store in Tulear, and visits to the wastes management company for plastic recycling and incineration of contaminated wastes.

Summary of activities

The RECM accompanied by the ECO under the leadership of the COP was well received by the stakeholders in the visited areas. The VectorLink Madagascar team has a very strong partnership with key players, such as the NMCP and USAID. Both organizations are working closely with the VectorLink Madagascar team, participating in the spraying campaign implementation in all steps; those parties also involve the VectorLink team in their activities when needed. The same case has been observed with all other parties, as they offered their full support, expressed their great appreciation, and also gave evidence of the reduction in malaria incidence, which they largely attributed to IRS.

However the National Office of Environment has made the strong recommendation to complete the screening template for the VectorLink project activities identification to make a decision about the assessment to do for the country side.

Working with the VectorLink Madagascar team on mHealth and environmental compliance was really interesting as the team was very proactive and engaged to reinforce those aspects, even though the last spraying campaign produced good results. Objectives, targets and results will be established, and red flags followed up for quick correction.

For the protected areas in each of two districts that were sprayed in 2018 the national park management team confirmed that they have not had any incidents related to insecticide use. Visiting protected areas have allowed me to understand the great challenges that the Vectorlink Madagascar team is confronted with when they have to cross over those protected areas and organic farms in vehicles and boats to access targeted zones without any incident.

During the visit to the central warehouse of Tulear, the team was engaged with the movement of commodities and insecticide from other districts, since those districts will be not sprayed and should be closed for 2019. Contaminated wastes and insecticides were stored separately from the other materials; some items were not yet arranged but the set-up was already pretty good.

The visit to the waste management unit, ADONIS was also fruitful. The great strength of this company is its ability to treat all categories of contaminated waste from the IRS activities. ADONIS, which carries out the collection, treatment and recovery of hydrocarbon waste and derivatives in Madagascar as well as medical waste, was able to incinerate all the expired insecticide in Mada and a part of wastes from the 2018 spraying campaign. The stock of empty bottles delivered to this site also was recycled.

The table in Annex D comprises the names of the people who were interviewed during the preparation of the SEA.

ANNEX D:
NAMES OF PARTICIPANTS

NAMES AND POSITIONS OF THE STAKEHOLDERS INTERVIEWED

Name	OFFICE – TOWN	FONCTION
ANDRIAMANANJARA Henriette	PNCM – Tana	Coordinator
RASAKOARIJAO Desire	Direction de la Protection des Vegetaux– Tana	Head of Phytosanitary Service
RANDRIAMIARANA Heritiana	ONE – Tana	DIRECTOR /Direction des Evaluations Environnementales (DEE)
RASAOMANANA Hery	ONE – Tana	UEIE/DEE/ONE
RAVONINJACOVO Andry	ONE – Tana	USPP/DEE/ONE
SOLOARIVELO Salohy	USAID – TANA	MEO
RAMANANTSOA Serge	USAID – PMI – TANA	CIL
ANDRIAMIHAMINA Jemima	USAID – TANA	PMA
VELONANDRO Syljeen Fidele	Madagascar National Parks (MNP)/ Sakara	Agent of Park Management (APM)
RAZAKARISON Sedera	MNP/Sakara	APM
Dr. ANDRIAMIARISVA Francis	Direction Regionale de la Santé	Director
HANOGNONA Hervé	Direction Regionale de l'Agriculture et l'Elevage	Directore
LYDORE Solandrozo	South West Region	Secretary General

ANNEX E:
SUMMARY OF ACUTE EXPOSURE SYMPTOMS & TREATMENT OF IRS PESTICIDES

Summary of Acute Exposure Symptoms and Treatment of WHO-Recommended Carbamate

Carbamates	Human Side Effects	Treatment
Bendiocarb	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.	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.
Propoxur	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.	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.

Summary of Acute Exposure Symptoms and Treatment of WHO-Recommended Organophosphates

Organophosphate	Human Side Effects	Treatment
Malathion	Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase. 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.	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 solution 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 nervous system stimulants are all contraindicated.
Fenitrothion	Fenitrothion is the most toxic to humans of the insecticides recommended for residual house spraying, and has a relatively low margin of safety. It is absorbed through the gastrointestinal tract as well as through intact skin and by inhalation and a cholinesterase inhibitor.	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.

Organophosphate	Human Side Effects	Treatment
Pirimiphos-methyl	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.	Organophosphate poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spray operators (in the case of dispersed operations) should be trained in first-aid and emergency treatment of organophosphate 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. 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.

Summary of Acute Exposure Symptoms and Treatment of WHO-Recommended Pyrethroids

Pyrethroids	Human Side Effects	Treatment
Bifenthrin	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.	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.
Deltamethrin	Deltamethrin is a powerful broad-spectrum synthetic pyrethroid. It is of moderate toxicity to mammals as it is rapidly metabolized and does not accumulate. It poses low risk to humans when used at levels recommended for its designed purpose. Deltamethrin exhibits its toxic effects by affecting the way the nerves and brain normally function by interfering with the sodium channels of nerve cells. Typical symptoms of acute exposure are irritation of skin and eyes and neurological effects such as severe headaches, dizziness, nausea, anorexia, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness. Tremors and convulsions have been reported in severe poisonings. Inhaled deltamethrin has been shown to cause reversible cutaneous paresthesia (a burning, tingling, or stinging of the skin). Limited data exist for humans following chronic exposures. However, the following effects are suspected to be a result of chronic exposures in humans: choreoathetosis, hypotension, prenatal damage, and shock. Chronic occupational exposure to deltamethrin causes skin and eye irritation. IARC has classified deltamethrin as “not classifiable as to its carcinogenicity in humans.”	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 with 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.

Pyrethroids	Human Side Effects	Treatment
Lambda-cyhalothrin	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.	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.
Alpha-cypermethrin	Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia. Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful.	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.
Cyfluthrin	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 twitching, convulsions, and coma.	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 with 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Etofenprox	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 twitching, convulsions, and coma may occur.	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 with 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.

Summary of Acute Exposure Symptoms and Treatment for Chlorfenapyr

Human side effects	Treatment
As chlorfenapyr is a rather new product there are not many cases of poisonings where the symptoms were described. One patient first exhibited general fatigue, hyper-perspiration, nausea, and vomiting. He was initially diagnosed as being dehydrated. Another patient initially presented with hyper-perspiration, headache, and cough. Symptomatic management was initiated, but after seven days she suffered neurological and respiratory deterioration, causing her death.	Symptoms following exposure should be observed in a controlled setting until all signs and symptoms have been fully resolved. If the substance was ingested, control any seizures first. Chlorfenapyr can produce abnormalities of the hematopoietic system, liver, and kidneys. Do not use emetics. Monitoring complete blood count, urinalysis, and liver and kidney function tests is suggested for patients with significant exposure. If respiratory tract irritation or respiratory depression is evident from inhalation, monitor arterial blood gases, chest x-ray, and pulmonary function tests. Significant esophageal or gastro-intestinal tract irritation or burns may occur following ingestion. Consider gastric lavage after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Activated charcoal binds most toxic agents and can decrease their systemic absorption if administered soon after ingestion. Immediate dilution with milk or water may be of benefit in caustic or irritant chemical ingestions. Rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury. Carefully observe patients with inhalation exposure for the development of any systemic signs or symptoms, and administer symptomatic treatment as necessary. If exposure is to the eyes, immediately irrigate exposed eyes with copious amounts of room temperature water (better with 0.9% saline solution) for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility. For dermal exposure, remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Summary of Acute Exposure Symptoms of Exposure to and Treatment of Clothianidin

Human Side Effects	Treatment
Clothianidin is a systemic insecticide belonging to the nitroguanidine subgroup of nicotinoid insecticides. It is also referred to as a chloronicotinyl or neonicotinoid.[i] Clothianidin and other neonicotinoids act on the central nervous system of insects as an agonist of acetylcholine, the neurotransmitter that stimulates nAChR, targeting the same receptor site (AChR) and activating post-synaptic acetylcholine receptors but not inhibiting AChE. The acute health risks to humans from exposure to clothianidin are minimal due to its low mammalian toxicity. Extrapolation from test results on animals to humans suggests that clothianidin is moderately toxic through oral exposure, but toxicity is low through skin contact or inhalation. Mild to moderate poisoning can cause nausea, vomiting, diarrhea, abdominal pain, dizziness, headache, and mild sedation. While clothianidin may cause slight eye irritation, it is not expected to be a skin sensitizer or irritant. Large deliberate ingestions have caused agitation, seizures, metabolic acidosis, coma, hypothermia, pneumonitis, respiratory failure, hypotension, ventricular dysrhythmias, and death. Rare caustic injury to the esophagus has been reported. This is likely due to the solvent component (N-methyl-2-pyrrolidone) of the insecticide, as opposed to the neonicotinoid itself. Clothianidin does not damage genetic material, nor is there evidence that it causes cancer in rats or mice; it is unlikely to be a human carcinogen. Submitted data also indicate that no significant adverse environmental impacts are expected to occur from the use of clothianidin.	MANAGEMENT OF MILD TO MODERATE TOXICITY Treatment is symptomatic and supportive. Administer IV fluids for hypotension. MANAGEMENT OF SEVERE TOXICITY Treatment is symptomatic and supportive. Treat hypotension with IV fluids; add vasopressors if hypotension persists. Treat dysrhythmias per ACLS guidelines. Consult a gastroenterologist for patients with pain on swallowing; drooling; or other evidence of caustic injury to evaluate for esophageal damage. Atropine should be considered if a patient is bradycardic, or experiencing cholinergic symptoms because these insecticides are frequently mixed with organophosphate and carbamate pesticides.

Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Clothianidin/deltamethrin Combination

Clothianidin/Deltamethrin combination	
Human side effects	**Treatment**
Local:, Skin and eye paresthesia which may be severe, Usually transient with resolution within 24 hours, Skin, eye and mucous membrane irritation, Cough, Sneezing Systemic:, discomfort in the chest, Tachycardia, Hypotension, Nausea, Abdominal pain, Diarrhea, Vomiting, Blurred vision, Headache, anorexia, Somnolence, Coma, Convulsions, Tremors, Prostration, Airway hyper reaction, Pulmonary oedema, Palpitation, Muscular fasciculation, Apathy, Dizziness	**Systemic treatment**: Initial treatment: symptomatic. Monitor: respiratory and cardiac functions. In case of ingestion gastric lavage should be considered in cases of significant ingestions only within the first 2 hours. However, the application of activated charcoal and sodium sulphate is always advisable. Keep respiratory tract clear. Oxygen or artificial respiration if needed. In case of convulsions, a benzodiazepine (e.g. diazepam) should be given according to standard regimens. If not effective, phenobarbital may be used. **Contraindication:** atropine. **Contraindication:** derivatives of adrenaline. There is no specific antidote. Recovery is spontaneous and without sequelae. In case of skin irritation, application of oils or lotions containing vitamin E may be considered.
Environmental Impacts	
In terrestrial environments, deltamethrin is not expected to be mobile, because it binds tightly to soil particles. It is insoluble in water, and recommended application rates are low. Volatilization from moist soils and biodegradation are major fate processes. However, volatilization is lessened by deltamethrin's tendency to adsorb to soil particles. As with other synthetic pyrethroids, deltamethrin degrades rapidly in soil and plants. It does not bioaccumulate in terrestrial systems. Very little leaching to groundwater is expected, because deltamethrin binds tightly to soil and is practically insoluble in water. Volatilization is a major environmental fate process in surface waters, but is lessened by soil adsorption. Deltamethrin breaks down quickly in water, with reported half-lives of 2–4 hours. It has a high potential to bioconcentrate in aquatic organisms.	

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