UNICEF Programme Cooperation Agreement

Environmental Remediation – Lead Poisoning in Zamfara

FINAL REPORT

September 2010 – March 2011

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ANNEX 4 of Programme Cooperation Agreement with Blacksmith Institute
Reporting Partner: Blacksmith Institute
Country: Nigeria

FINAL REPORT
No. and title: PCA Ref: **YW-303 (01)** Final Report on Environmental Remediation – Lead Poisoning in Zamfara
Reporting period: September 2010 – March 2011

I. PURPOSE

I. A. BACKGROUND

In March 2010 Medecins Sans Frontieres (MSF) discovered an epidemic of lead poisoning in Zamfara state in northern Nigeria. Subsequent investigations by the Centers for Disease Control (CDC), the World Health Organization (WHO) and the Zamfara State Ministry of Health (ZMoH) confirmed that hundreds of children under age five years were at risk of death or serious acute and long-term irreversible health effects due to extremely high levels of lead and mercury. At least 10,000 people were estimated to be affected overall. The source of the outbreak was associated with artisanal gold ore processing that occurs in the villages. For several months grinding operations were conducted at numerous sites in villages and crushing, washing, and gold recovery were undertaken within the residential compounds. A particularly dangerous ore, of high lead content sometimes exceeding 10% lead, was introduced into the processing stream in early 2010. In early April 2010, when death and illnesses became prevalent, the Emir of the area ordered these operations moved outside the residential areas approximately ½ kilometer from the villages. Extremely hazardous exposures associated with residual wastes and contaminated soils remained in the home compounds and exterior processing areas.

In May, at the request of the Zamfara State government, the United States (US) and Nigerian CDC conducted an assessment of the extent of the epidemic. At the request of the CDC, the USA firm TerraGraphics Environmental Engineering (TG) and the international NGO Blacksmith Institute (BI) assisted with and provided equipment and expertise in this survey. The assessment confirmed the lead poisoning diagnosis and 163 deaths among children less than five years of age in two villages, tested several hundred children and adults, identified the principal exposure routes, and quantified contamination levels in environmental media in the villages.

The ZMoH, CDC, WHO, MSF and Nigerian federal authorities collaborated to develop a medical response protocol for affected villages. The primary treatment protocol was developed by MSF to provide oral chelation therapy for children five years of age and under. Initially, treatment was provided in hospitals developed by MSF in Bukkuyum and Anka Local Government Areas (LGAs). Subsequently, an out-patient chelation protocol was adopted and administered from local clinics established in the villages.

It is universally recognized that the efficacy of chelation therapy is compromised if medically treated children return to contaminated homes. Relocation of families or long-term foster care in clean villages was not a viable option in this society. This necessitated immediate remediation of the villages to secure clean environments for the children returning from treatment. In addition, the chelation option is only made available on a priority basis to children 0-5 years of age. Any reduction in lead exposure to older children, adults, and particularly women of reproductive age must be achieved through remediation of the villages and sustaining the resultant clean environments.

In response to a request for technical assistance from the ZMoH and the Zamfara Ministry of Environment and Solid Minerals (ZMoE), TG and BI developed an emergency remediation plan that was initiated in June of 2010 at the villages of Dareta and Yarlgama in Anka and Bukkuyum LGAs. This work is known as Phase 1 of the overall remediation program and was conducted under a series of protocol documents negotiated with the ZMoE entitled *"Emergency Cleanup Strategy for The Villages of Dareta and Yarlgama, Zamfara State, Nigeria –Lead Poisoning Epidemic – June 2010."*

The Phase I cleanup work was conducted by the ZMoE with the technical guidance and assistance of TG. The work was funded by a combination of Zamfara State, TG and BI. The cleanup continued until work was suspended due to the onset of the rainy season in mid-July. As a result of Phase 1 activities, MSF was able to provide chelation treatment for nearly 1000 children commencing in mid-June and continuing through the rainy season.

I. B. PHASE 2 REMEDIAL ACTIONS

At that time, five other villages had been identified where significant artisanal mining had occurred using the same contaminated ores and unsafe practices. Little to no environmental sampling or characterization of the extent of contamination and lead poisoning had been conducted prior to late 2010. Nevertheless, cost estimates were developed to undertake remediation in these villages beginning in September following the rainy season. These estimates were based on the same protocol, staffing, and collaborative relationship among the Zamfara State and international entities involved in the Yarlgama and Dareta cleanups; and specifically exempted remediation of water related media.

Under this partnership, Phase 2 remedial activities were undertaken in mid-September. Two main work elements were involved in Phase 2 remediation activities: i) under the Joint United Nations Environment Program (UNEP) and Office for the Coordination of Humanitarian Affairs (OCHA) (JEU), the Dutch government provided a mobile team of water quality experts to assess the extent and degree of water source contamination in the affected villages, and ii) the TG/BI team was retained to continue soil and mining waste remedial activities at the five villages under the protocols established with the ZMoE in June/July 2010. The latter work was to be conducted under this UNICEF PCA in collaboration with the Zamfara State government, LGAs and Emirates. The PCA remedial activities were described in a series of amended protocol documents provided in earlier progress reports entitled "*Strategy for Cleanup of Five Villages In Bukkuyum And Anka Local Government Areas (LGAs), Zamfara State, Nigeria –Lead Poisoning Epidemic - September To December, 2010."*

The PCA work included the remediation of five villages - Tungar Guru, Abare, Tungar Daji, Sunke ("Kasunke") and Duza. **Figures 1-7** show maps of Nigeria, Zamfara state and the 5 villages remediated under CERF. In early December the PCA was amended to include limited work in a sixth much larger village, Bagega; and the completion date was extended to accommodate unforeseen delays and additional scope. Decontamination efforts funded by this PCA included individual compounds, village and common areas, and village exterior locations where processing had occurred in the five villages; and construction and closure of landfills to accommodate the waste at each village. Additionally, in Bagega, the amended PCA called for development of a landfill, installing access controls to the industrial mining compounds, and remediation of high risk compounds, as determined in collaboration with MSF/ZMoH response activities.

All work in both the five villages and Bagega has been completed. A total of 282 residential compounds, 107 exterior areas and 23 processing ponds have been remediated in the five villages. See Section III. B.3.2. and **Table A** for details. In Bagega, a large landfill has been constructed and prepared to accept contaminated soils and industrial waste; and residential areas, common area village exteriors, brick-making ponds and the Bagega Industrial Site have been characterized. Preliminary design and cost estimates have been prepared to support the anticipated Phase 3 remediation effort addressing Bagega.

Additional work beyond the scope of the CERF PCA was also accomplished during Phase 2 activities using funds from other partners– notably, i) the removal of highly contaminated materials from 7 ponds in Yarlgama and Dareta that were being used to make bricks for compound repairs following a particularly damaging rainy season, ii) establishment of male and female advocacy programs to facilitate remediation and support prevention of recontamination, iii) initiation and incorporation of village, LGA and community response activities, iii) training and technology transfer to more than 200 Ministry, LGA village and private entity personnel to establish remedial capacity in the State, and iv) providing guidance and assistance to a new State Agency to address mineral processing activities.

For the purpose of completeness and context, this report describes the comprehensive emergency removal response to the crisis in Zamfara, beyond that funded by the UNICEF PCA. The portions related to fulfilling the elements of the PCA are clearly identified. It is anticipated that additional phased remedial actions will also be required to address i) other villages in Zamfara known to have engaged in artisanal mining; ii) contaminated water features; ii) development of source control, best practices, and facilities to support responsible mining activities in the artisanal sector; and iv) follow-up investigations to assess remedial effectiveness of the applied measures.

I. C. EXPECTED RESULTS

The work accomplished under this PCA had three primary goals that have been achieved: i) **Exposure Reduction** - the village cleanups have markedly reduced lead and mercury exposures and the risk of mortality and significant adverse health effects among an estimated combined population of 8551 (6385 in the 5 CERF villages and 2166 in the 2 Phase 1 villages) (See **Table B**); ii) **Facilitating the MSF/ZMoH Treatment Program:** the work has allowed MSF to provide clinical services to several hundred families and institute chelation treatment for approximately 1000 children five years old and under, as of January 2011 (See **Table C**); and iii) **Capacity Building:** the capability of Zamfara and local entities to undertake future cleanup activities has been established, and the villagers are increasingly aware of the dangers of artisanal mining and the measures required to protect their families.

A large compliment of Zamfara State and LGA staff has been trained to manage and supervise the remediation program. Several hundred villagers and local suppliers have been provided jobs and acquired experience in implementing the remedial protocols. The ZMoE has established a new agency to undertake remediation and regulate artisanal mining processing. Anka LGA, Emirate and Bagega village officials have established committees to address artisanal mining, prevent resumption of dangerous activities, and control recontamination in the villages.

In addition, Bagega has been comprehensively characterized, design and cost estimates have been developed, and a landfill prepared to accept wastes. Pending requisite funding, the work sponsored by this PCA has, in collaboration with Zamfara State and the LGAs, developed the capacity to undertake and sustain future cleanup activities in Bagega and other impacted villages. See Sections III. B.3.4. and III. B.3.5. for detailed discussions of these results.

I. D. LINKAGES TO UNDAF and the MDGs

According to the United Nations Development Assistance Framework II for Nigeria formalized in September 2008, UN assistance in Nigeria has added specific benefits that support government initiatives to reduce poverty. In regards to Nigeria, UNDAF states "…key strengths of the UN are seen to lie in the provision of advisory assistance, technical expertise, support for capacity development and as a trusted intermediary between partners[1].” This project has directly incorporated these aspects as critical to the successful implementation of program activities. Advisory assistance and technical expertise were provided to Zamfara State environmental and health officials in lead risk mitigation, decontamination and remediation management. Critical to the methodology of the program was ensuring that local officials retained the capacity to continue remediation activities after the departure of the international team. This program trained nearly 50 state and local officials to undertake actions necessary to mitigate lead exposures in these communities. According to the IMF’s Poverty Reduction Strategy Paper (PRSP) for Nigeria, national ownership of UNDAF is critical to the achievement the Millennium Development Goals (MDGs) by 2015. Government collaboration and acceptance of technical assistance throughout this project has fortified its commitment to achieve several MDGs.

Specifically, this project addresses MDGs dedicated to reducing child mortality, improving maternal health, and building a global partnership for development. Child mortality from lead exposure was significantly reduced in remediated villages due to the identification of contaminated areas and the removal of lethal lead levels in residential soils. This intervention also decreased the risk of lead poisoning to fetuses and children by diminishing lead exposures to pregnant and nursing women. Additionally, an international coalition responded to this crisis to provide a comprehensive response to the Government of Nigeria in its efforts to address environmental, health and livelihood concerns. This international partnership is committed to building local and national capacity to appropriately address current and possible future lead poisoning outbreaks related to mining activities.

[1] United Nations Development Assistance Framework (UNDAF) II – Nigeria 2009 – 2012, Abuja, September 2008

II. RESOURCES

The total approved budget for the PCA is US $1,074,987 (reflected in the December 2, 1010 amendment). UNICEF provided $994,312, while Blacksmith contributed US $80,675. All budgets under the programmatic document are funded. Significant additional funding and in-kind contributions were secured for both the Phase 1 effort and to augment Phase 2 activities from Zamfara State, Anka Emirate, MSF, Blacksmith and TG. By project closure in the first week of March, approximately $2.3M USD dollars will have been spent in village soil remediation in Phase I (Dareta/Yarlgama) and Phase II/CERF (five Villages/Bagega) through the efforts conducted under the technical advice of TG/Blacksmith. This total includes this PCA of US $994,312 from UNICEF/CERF/WHO, and approximately US $400,000 by the State of Zamfara and Anka Emirate, US $240,000 by MSF, US $170,000 by Blacksmith, and US $500,000 by TG in personnel, equipment, donated services and costs incurred in supporting the remediation. It is expected that a similar amount will be required to remediate Bagega and the associated Industrial Area.

These estimates include only money, services and resources applied directly to soil and mine waste remediation (i.e., funding directly applied to design, implementation and oversight of decontamination and clean soil replacement). It does not include monies and resources that numerous agencies have contributed to health, education, communication, health and environmental assessment, treatment, development of response capacity, and other aspects of the larger project. This Figure does not include expenditures by OCHA in Phase 2 water source assessment conducted in October, as these costs are unavailable to TG/Blacksmith.

III. RESULTS

III. A. ASSESSMENT OF WORK COMPLETED

All activities projected under the UNICEF PCA have been completed. See Section III. B for a detailed summary of remedial items addressed.. This work has been successful in achieving substantial reductions in ongoing exposures, providing opportunity for implementation of medical treatment, developing significant remediation capacity in the ZMoE and LGAs, and soliciting the cooperation and involvement of villagers in implementing and sustaining the remedy.

III. A. 1. Exposure Reduction

These remedial activities have significantly reduced ongoing exposures to the entire village populations. Because these exposures and consequent blood lead levels are unprecedented and higher than any known in the lead health literature, nearly all village residents tested to date show dangerously high blood lead concentrations. Initial blood lead levels for children 5 years old and under entering treatment from the Phase 1 villages were greater than 140 ug/dl, with individual readings exceeding 700 ug/dl (See **Table C** and **Figure 8**).

Reducing these exposures as soon as possible was, and remains, critical for several reasons: i) MSF now has access to approximately 1000 children five years old and under to commence chelation therapy, ii) exposures to other village residents have been reduced by an estimated 98% (See Sections III. B.1.3 and III. B.4.2), iii) new village residents and children born to mothers with low body burden will not experience high exposures; and iv) these other village residents represent additional populations at risk of significant health effects, who are receiving no other form of medical or health intervention, apart from exposure reductions achieved through remediation.

The most significant potential effects include adverse reproductive and child development outcomes; i.e. exposure to pregnant women (as surrogates to the fetus), newborns and breastfeeding infants, older children, teenagers marrying and commencing reproductive activities. Adult reproductive effects in both males and females include miscarriages and spontaneous abortions, depressed sperm counts and decreased fertility are likely. Potential central nervous system (CNS) outcomes for the fetus and young children include irreversible neuro-psychological effects ranging from severe brain damage resulting in permanent dysfunction, to depressed mental capacity, impairment of nerve function, behavioral and learning problems, loss of quality of life, and inability to participate in or meet village social obligations. There is also a range of potential damage to other organ systems at these blood lead levels and body burdens. An entire generation of village residents is at risk of debilitating effects that threaten the ability of these communities to meet the minimal functions of organized social structure.

Ongoing external exposures to these populations have been reduced by similar percentages, significantly augmenting the prognosis for recovery from these events. However, extremely high historic exposures over the past three years of heavy mining activities and the residual contaminated soils in villages have resulted in significant body burdens of lead. Reducing these cumulative lead stores in the bone may require several years to equilibrate with lowered exposures. The fetal skeleton develops from the mother's bone store and the infant is born with a blood lead approximating the mother. The population of current mothers and young women entering marriage and motherhood with blood lead levels in excess of 40 ug/dl represent an especial risk to future generations, also unprecedented in lead poisoning prevention programs anywhere in the world. Achieving the lowest possible exposures in the villages, and assuring proper nutritional status and general health conditions, are the most effective relief that can be offered to these women and children.

III. A. 2. Facilitating the MSF/ZMoH Treatment Program

Cleanup of Yarlgama and Dareta villages was completed in early July 2010. Remedial activities in these villages were closely coordinated with MSF. At that time, the MSF chelation protocol was a nineteen day in-patient course conducted at the hospitals in Bukkuyum and Anka. MSF began recruiting and treating children in both villages in mid-June. MSF notified TG/BI from which compounds the children were recruited. TG/BI scheduled the completion of those compounds prior to the children being released from the hospital. Completion of remediation in the Phase 1 villages in July made children $\leq$ 5 years old eligible for treatment in the two villages through the rainy season. **Figure 8** shows the reduction in blood lead levels for the first cohort of children provided treatment from the Phase 1 villages. Section III. B.4.3. discusses the results in more detail.

Remediation of Phase 2 villages commenced the first week of October 2010 in Abare; additional villages were added in successive weeks. MSF initiated out-patient treatment in these villages as compound remediation was completed. As shown in **Table E**, Abare and Tungar Guru were functionally complete in the week of November 21, 2010, Sunke, Tungar Daji and Duza were complete in the week of December 12, 2010. In total as of January 2011, nearly 1000 children five years of age and under were being treated. In March MSF will occupy the TG/BI compound in Bagega to provide outreach services to Tungar Daji and Duza. Approximately 1500 children five years of age and under are believed to live in Bagega and many of them likely have blood lead levels exceeding MSF's chelation criteria.

There were significant difficulties in tracking compound and individual data in Yarlgama and Dareta in Phase 1, due to CDC, TG/BI and MSF maintaining separate maps and databases. TG/BI and MSF have coordinated mapping and collection of demographic and compound information to facilitate data and case management in Phase 2, and have reconciled compound and village mapping in Dareta.

There have been limited attempts at blood lead follow-up in Dareta. Environmental follow-up of children who were not responding to chelation therapy revealed in two cases that limited processing had occurred in the compounds. In those cases, LGA and Emirate authorities compelled the head of household to discontinue processing and self-remediate the damage. In a third case, the children were found to be visiting the processing area near the family farm and mimicking the miners in play activities. The parents were advised to discourage this behavior. Additional follow-up has been suspended pending resolution of mining and processing controls to avoid alienating participating families.

III. A. 3. Capacity Building

It is important to note the limited capacity of the ZMoH and the ZMoE to respond at the onset of the crisis, coupled with a minimal level of technology that could be implemented by village labor. ZMoE staff had no experience with either lead poisoning or remedial response activities. Access to the villages was severely restricted, requiring several hours to reach some villages over nearly impassable roads. Access to heavy equipment, typically required in such a response, was extremely limited, expensive and initially unreliable from local contractors. This was resolved as Chinese mining companies in the area were able to provide dependable, yet expensive equipment. Acquiring and maintaining functional vehicles to transport staff over the substandard roads was a major obstacle, expense and constant challenge. Similarly, the medical/clinical response was in a triage setting – only the children 5 years of age and under are being treated due to limitations of both chelation drug supplies and staff to provide services in such remote villages. The remote setting and lack of standard hospital facilities has required substantial modifications of chelation treatment protocols to meet the reality of the available resources condition of facilities in Zamfara.

As a result, it was also prudent to develop remediation protocols that could be implemented and sustained in a manner compatible with the technological capabilities of the villagers. It was noted that these agrarian communities are capable of moving large amounts of soil using rudimentary techniques based on hand labor, use of locally manufactured hoes, wheelbarrows and headpans, and are adept in transporting products and raw materials in readily available agricultural sacks. The remedy was designed to utilize local labor and skills to the maximum extent practicable. In addition, employing villages residents provided a much needed supplement to local incomes in this desperately poor region. The provision of local employment, purchase and manufacture of local tools and supplies and utilization of State and LGA managerial and supervisory personnel laregely contributed to the high degree of local cooperation obtained in implementing the program at the village level.

III. B. MAIN ACTIVITIES UNDERTAKEN AND ACHIEVEMENTS

III. B. 1. Development of the Environmental Response Protocol

The remediation protocol was provided in the series of documents attached to the **SUMMARY OF RECOMMENDATIONS** provided to UNICEF in previous progress reports entitled "*Emergency Cleanup Strategy for Five Villages in Bukkuyum and Anka Local Government Areas (LGA), Zamfara State, Nigeria –Lead Poisoning Epidemic – September To December, 2010"* by TerraGraphics Environmental Engineering.

The appended documents include the following:

i) ZAMFARA SITE CONTROL PLAN – **Phase 2 Village Cleanups**
ii) ZAMFARA EXCAVATION PLAN – **Phase 2 Village Cleanups**
iii) ZAMFARA LOGISTICS AND DISPOSAL PLAN – **Phase 2 Village Cleanups**
iv) ZAMFARA PROJECT COST ESTIMATE – **Phase 2 Village Cleanups**

III. B.1.1 The Response Model: The remedial strategy employed for this PCA is based on US experience obtained from addressing similar lead poisoning epidemics. The US Superfund program to cleanup abandoned hazardous waste sites provides a template for applying lessons learned in those programs to low and middle-income countries.

Although often described as a "remediation project", the cleanup work in Zamfara is more appropriately characterized as an "emergency removal" and is corollary to "triage" in medical response. The technical term remediation or "remedial action" suggests that the site has been fully characterized, all environmental exposure pathways are identified and quantified, a risk assessment has been performed, appropriate cleanup limits established, and a feasibility study has been conducted to assess the most efficient means and protocols to implement the remedy. In Zamfara, the project began while children were dying of lead poisoning in unprecedented numbers, and thousands of children were at risk of death or severe brain damage. UN, European or US authorities had limited experience in dealing with exposures of this magnitude or severity. The Nigerian government had neither the capacity nor expertise to deal with a lead poisoning epidemic in these remote areas.

As a result, and at the request of the Zamfara State government, the TG/BI team proposed and implemented a response strategy based on previous US and international experience. TG has considerable experience in lead health emergency response and remediation in the US. The TG Project Manager for this PCA has 37 years of experience and expertise in remediating one of the most contaminated US lead poisoning sites, the former Bunker Hill Company mining and smelting complex in the state of Idaho. He has served on several CDC, US

Environmental Protection Agency (USEPA) and Housing and Urban Development (USHUD) advisory boards regarding lead health response, abatement and remediation. In the 1970s, more than one thousand children were severely lead poisoned following a fire at the Idaho, USA smelter. Children under five years of age at the Bunker Hill site had average blood lead levels of 70 ug/dl. Over the course of two decades of combined emergency response, health intervention and remedial actions, average blood lead levels were reduced to <2 ug/dl. TG has characterized, assessed, developed, implemented and provided oversight for more than US $500 million in remedial action, in this the largest residential cleanup undertaken in the US.

In 2005, the US National Academy of Science (NAS) conducted the most intense review of a mining site remediation ever undertaken, "*Superfund and Mining Megasites – Lessons Learned from the Coeur d'Alene Basin" (NRC, 2005*). This review examined in detail the effectiveness of the human health remedy applied at the Bunker Hill site. The following is among the committee's conclusions:

> ***The committee found that the scientific and technical practices used by the USEPA for decision making regarding the human health risks at Coeur d'Alene River Basin Superfund site were generally sound. The exceptions are minor. However, for the USEPA's decision making regarding environmental protection, the committee has substantial concerns, particularly regarding the effectiveness and long-term protectiveness of the selected remedy.***

In summary, the NAS concluded that the health remedy was well conceived and executed. However, the panel expressed concerns with the sustainability of the cleanup, the need for repository space, and the proposed groundwater and ecological remedies. These conclusions have particular relevance to the Zamfara situation. Much of the Bunker Hill site remedy relied on *in situ* stabilization of wastes with reliance on Institutional Controls (rules and regulations) to ensure long-term maintenance and enforcement of site use prohibitions to prevent re-contamination. The NAS was skeptical of the US and Idaho State governments' ability to enforce these requirements in perpetuity. Similarly, the capability of the Nigerian, Zamfara State, LGA, and traditional governments to implement long-term prohibitions was in doubt. As a result, complete removal of contaminants was favored in designing the remedy for the villages.

Following the NAS study, TG and the University of Idaho (UOI) undertook an International Initiative to adapt the lessons learned during the Bunker Hill experience and apply those within the cultural, social and resource capabilities of developing countries. In 2007, the TG/UOI program entered into a collaborative effort with the Blacksmith Institute to apply the International Initiative to sites identified by Blacksmith. Between 2007 and 2010 collaborative cleanups of mining and lead contaminated sites were undertaken in Russia, China, Dominican Republic and Senegal. The experience obtained in implementing effective emergency response and remedial actions at these diverse sites was invaluable in developing the cleanup protocols for Zamfara.

III. B.1.2. Identification of Principal Exposure Routes and Risk Assessment: The response action undertaken in both Phase 1 and 2 of the Zamfara project was based on this successful US model of health intervention, emergency removal, advocacy, clinical treatment, and follow-up. All of the measures aim to reduce exposure to the population by reducing the intake of lead along the main exposure routes. A similar pathways model was utilized in Zamfara, identifying and removing soil/dust pathways to mitigate lead exposures.

The primary exposure routes for children and adults identified in these villages are: i) incidental ingestion of contaminated soils and dusts, ii) consumption of food contaminated by soil and dust sources, iii) ingestion of contaminated water, and iv) inhalation of contaminated dusts.

Nearly all villagers are subject to lead intake from these routes to varying degrees, depending on concentration, individual habits, proximity to sources, etc. Other routes for particular individuals have also been identified, but not quantified, including plant and animal uptake and cosmetics. However, the overwhelming sources requiring emergency mitigation are associated with soil and dust pathways contaminated by high concentration mineral processing wastes. The main exposure routes are described briefly below.

Incidental ingestion of contaminated soils and dusts*:* Incidental ingestion of soils and dusts has been studied extensively for young children in temperate climates in developed countries. For 6 month to 5 year old children, these soils are largely ingested through hand-to-mouth activities, i.e., young children mouthing their fingers and various play objects during oral exploration of their environment. Typical ingestion rates in the US are from 100 to 200 mg/day for 1-5 year-old children. Absorption rates (the percent of lead absorbed into the body) for lead ingested from soils and dusts vary from <5% to 40% depending on chemical species, particle size, matrix characteristics; and children's nutritional, anemia status and pre-disposition to other disease. The USEPA clean soil criterion for children is 400 mg/kg and is based on a 30% absorption rate. This results in a typical allowable intake and uptake of:

100 mg/day * 400 mg/kg Pb = 40 ug/day Pb intake * 30% absorption = 12 ug/day Pb uptake

Bio-kinetic modeling of this uptake in equilibrium conditions will result in a typical blood lead level of 2-4 ug/dl in young children.

In these villages, children's soil ingestion rates are unknown, but may well exceed 1 gram/day or five times developed country rates. In the Nigerian villages, children live, eat and play in dirt floored compounds, without running water and only limited hygiene. Many of these children are malnourished, have limited calcium and vitamin sources in their diets, are subject to fasting between meals, are anemic, and likely have malaria and other ailments. (In October 2010, 90% of the patients at the MSF outreach clinic in Dareta had malaria). Typical lead concentrations averaged for all soils these children encounter in a day often exceed 5000 mg/kg lead in an oxidized carbonate species. As a result, absorption rates are likely in the highest range, possibly exceeding 30 percent. The incidental ingestion estimate for typical village children yields:

1000 mg/day * 5000 mg/kg Pb = 5000 ug/day Pb intake * 30% absorption = 1500 ug/day Pb uptake

At these extreme intake levels, uptake mechanisms in the body may be saturated. Nevertheless, the intake from soil/dust is more than 100 times the US criteria and could conservatively result in blood lead levels exceeding the 70 ug/dl hospitalization criteria from this source alone. Higher soil lead concentrations observed in numerous compounds, and contaminated food and water sources can readily exacerbate absorption into the hundreds of ug/dl levels observed.

Food sources: Limited sampling suggests foodstuff can be severely contaminated during processing. This is due to both the presence of contaminated soils and dusts in the compounds and the shared use of utensils for both food preparation and mining operations. An example of potential intake/uptake rates for young children follows:

100 gr/day of millet * 20 ug/gr Pb = 2000 ug/day Pb intake * 40% absorption = 500 ug/day uptake

This source alone could result in blood lead levels of 30 -50 ug/dl or greater. Food contamination levels in excess of 2-3 mg/kg will significantly add to body burden. However, it should be stressed that the suspect sources of lead contamination in food are the same soil, dust and mining residue sources impacting the incidental ingestion pathway.

Water sources: OCHA testing indicates that well water in these villages range from 10 to 50 ug/l Pb and that surface water sources range to 200 ug/liter Pb. The US standard for delivered potable water is 15 ug/l and targets the same outcome blood lead levels as the soil criteria. Children in these hot climates may consume up to 2-3 liters of water per day (2-3 times developed country estimates). This results in a typical intake from water in the following range:

2 liter/day water * 10 ug/liter Pb = 20 ug/day Pb intake * 50% absorption = 10 ug/day Pb uptake, to
3 liter/day water * 50 ug/liter Pb = 150 ug/day Pb intake * 50% absorption = 75 ug/day Pb uptake

<u>The water source alone would result in blood levels exceeding 10 ug/dl</u>, but are of lesser significance than the soil and dust and contaminated food sources.

III. B.1.3. Risk Management Strategy: The preliminary risk assessment indicates that the overwhelming source of contamination for the villagers is contaminated soils and dusts in the home compounds and village common areas. The basic approach to decontamination is to remove contaminated surface soil and wastes from the villages, replace those areas with clean soils, and dispose of the wastes in secure landfills. The remediation was implemented by Zamfara State, and the LGAs, employing village labor using techniques and procedures familiar to the local population.

Cleanup Criteria: The following cleanup criteria are applied:

- All soils greater than 1000 mg/kg (or detectable Hg) are removed and replaced with soils containing less than 100 mg/kg Pb (generally <60 mg/kg Pb)
- Contaminated soils between 400-1000 mg/kg lead are covered with 8 centimeters of compacted clean soil.
- Soils in the 400-1000 mg/kg range can be excavated at the Village Cleanup Director's discretion.
- Replacement clean soils are required to be less than 100 mg/kg lead.

These techniques are designed to result in significant reductions in lead intake via the soil/dust ingestion routes and to reduce the contribution of these sources to food sources. Post-remediation soil lead concentrations are less than 100 mg/kg lead for nearly all exposed soils in the villages, inside and outside of compounds. This results in an estimated post-remediation intake from incidental soil and dust ingestion:

1000 mg/da * 100 mg/kg Pb = 100 ug/day Pb intake * 30% absorption = 30 ug/day Pb uptake

Successful implementation of this strategy results in a 98% decrease in lead intake and uptake due to incidental ingestion. This level of intake can result in blood lead levels generally in the 5-20 ug/dl range, and some children may exceed the 10 ug/dl health criteria due to the high ingestion rate assumed for this population.

A similar reduction in foodstuff contamination can be expected, if utensils are thoroughly cleaned or replaced, all forms of mineral processing are eliminated from the village, and miners don't bring ore home on their clothes and person.

Remediation Protocols: Extensive soil surveys show that the contaminants are largely contained in the top 5 centimeters of surface soils overlaying sub-soils densely compacted by village foot traffic. These contaminated soils can be removed in an effective manner using agricultural tools, mimicking village farming practices. Contaminated soils are bagged in readily available sacks and transported to constructed landfills. The contaminated soils are replaced with clean soils of suitable compaction quality at all excavated surfaces.

The replacement soils offer a low-lead soil and dust exposure ingestion source to children, act as a barrier to any remaining sub-surface contaminants, and dilute any contamination remaining in other soil/dust pathways following excavation. These soils become densely compacted by villagers and livestock traffic, forming a concreted surface that performs a barrier function and promotes runoff during the rainy season. This procedure is applied inside the home compounds and in exterior locations inaccessible to mechanical equipment.

Process wastes from former ore processing and storage, mining and mineral extract locations are excavated (by heavy equipment, if accessible) and disposed of in the landfill. These areas are also returned to grade with compacted clean soils. Wastes and contaminated soils are placed in a constructed landfill, compacted and covered with a one-meter cap of compacted local clays and suitable cover material. The buried material is largely low concentration lead-contaminated soils (generally .1 to 1% lead on average), with individual loads ranging to 10% lead. Some mineral processing wastes exceed 10% lead. These wastes are inorganic, weathered, oxidized galena lead compounds, likely of low solubility in natural environments and typical pH. The landfills are constructed in dense clays with low permeability, above the water table and remote from wells or streams; minimizing the probability of significant leachate production, transport, or release to the environment, thus avoiding the need for liners.

III. B.2. Pre-remedial Contamination and Toxicity Levels

III. B.2.1. Compounds, Village Common Areas, Processing Areas and Ponds: Intensive sampling of all villages was accomplished prior to, or as remediation was initiated. **Tables A** and **D** show the number of compounds, exteriors and ponds evaluated in the course of Phase 1 and 2 activities. See also **Figures 3-7** for detailed village compound delineations. Examination of **Tables A and D** shows that a total of 495 compounds were assessed in the seven villages. Of these, 430 (87%) required remediation (i.e., soil lead levels exceeded 400 mg/kg lead). Of the 333 compounds in the 5 CERF villages, 282 (85%) required remediation. Of these 282 compounds, 21 (7 %) had maximum soil lead levels >100,000 mg/kg with a high of 379,113 mg/kg; 41 (15%) had levels between 25,000-100,000 mg/kg; 48 (17%) had levels between 5,000-24,999 mg/kg. In addition, all exterior areas in the villages were tested and characterized. Approximately 10,000 square meters of 107 contaminated exterior common and process areas required remediation, with the majority exceeding 5000 mg/kg lead. All ponds in the villages were tested. Ponds used in washing ores were all found to have lead levels exceeding 5000 mg/kg lead with some up to 50,000 mg/kg lead and more than 2000 mg/kg mercury. A total of 30 ponds were drained and excavated, 23 in the 5 CERF villages and 7 in Phase 1 villages.

III. B.2.2. At-Risk Populations: Table B provides pre-remediation population exposure estimates for the seven villages and Bagega. Nearly 16,000 people may be affected by the mining-related contamination in these villages. Of those, more than 3000 are children under 5 years of age. (This is based on a US CDC methodology, which estimates that 20% of a population is in this age group; this estimated is confirmed by the 2006 Nigerian federal census). Although this age group is the only group to which MSF is able to provide chelation treatment at this time, as noted above, other sensitive populations reside in these communities. At this time their only reduction in exposure is due to the removal of contaminated soils. The potential numbers of people affected are estimated to include:

- 3200 children under 5 years
- 600 pregnant women of childbearing age as surrogates for fetus each year
- 1300 breast feeding infants each year
- 1300 breast feeding mothers each year
- 2800 children 5-9 years of age
- 3500 children/teens 10-19 years
- 7600 adult males and females
- 600 menopausal women

Also noted in **Table B**, more than 7000 of the 16,000 total population reside in Bagega, for which there is currently no funding for either remediation or clinical intervention.

III. B.3. Village Cleanup Activities

III. B.3.1. Mobilization and Completion Schedule by Village: Table E shows the overall completion schedule for major tasks undertaken in Phase 2 activities remediation activities accomplished under the PCA. Those major tasks include:

- Sampling and Characterization
- Landfill Construction Clean Soil Borrow
- Interior Remediation
- Exterior Remediation
- Ponds
- Process areas
- Landfill Closures

The schedule and budget were driven by the availability and logistics associated with the heavy construction equipment; the unknown extent of contamination in exterior processing areas; village ponds used in washing ores; and maintaining a fleet of vehicles capable of delivering managerial and supervisory personnel, supplies, and equipment to the remote villages.

Procurement and Heavy Equipment*:* The heavy equipment including an excavator, payloader and 2 15-cubic meter tippers operated on an independent schedule from the village excavation crews. Independent scheduling was due to the extraordinary expense associated with equipment rental relative to labor costs in Zamfara. Heavy equipment was procured the week of October 3 and landfill siting and construction commenced the following week. Landfills and clean soil borrow sources were developed successively at Abare, Tungar Guru, Sunke, Tungar Daji, and Duza by the week of October 31. This was followed by development of the Bagega landfill and demobilization of the excavator and large tippers the week of November 14, well within schedule and budget. The payloader was retained in Abare through the week of October 31 and then moved to Sunke to service clean soil needs in Sunke, Duza and Tungar Guru. The payloader was demobilized the week of December 12, as most of the compound remediation was completed prior to the holiday break taken the weeks of December 19 and 26.

Holiday Break / Ponds / Brick-making: The holiday break was unavoidably extended through the week of January 9, due to violence in Anka associated with a local election. Work did not re-start until the week of January 13, resulting in nearly a month long hiatus in remedial activities. It was planned at that time to secure a different payloader or backhoe capable of maneuvering and scraping soils in the village exterior areas. However, no dependable source of such equipment was located and the project relied on hand labor to excavate exteriors following the break. This extended the schedule, but was well within the budget. However, initial return visits to the villages mid-January following the lockdown revealed that several ponds had dried up in the Harmatan and villagers were actively making bricks from the contaminated pond sediments. The previous rainy season had been especially damaging to mud-structure buildings and walls in the villages, and the residents were hard-pressed to make repairs before the March/April rains.

This finding was of enormous significance. These ponds had been used for sluicing and washing of processed ores. Villagers also disclosed that excess ores had been discarded in the ponds to avoid enforcement during the Emir's prohibition on processing in the villages the previous April. Testing of the bricks often showed 3-7% lead content with mercury levels exceeding 200 mg/kg. Numerous villagers were preparing to repair walls and buildings damaged in the last year's unusually harsh rainy season using these contaminated bricks. Failure to address the problem of the villagers working in these materials, rebuilding the compounds with these wastes, and re-contaminating their homes would have negated the entire remediation and treatment effort. See the discussion in Section III. C.2.12.

Addressing the ponds required re-mobilizing the heavy equipment to excavate the pond bottoms. The excess volumes of waste generated required extending the landfills at Sunke and Dareta and trucking waste from Tungar Daji to Duza and Yarlgama to Tungar Guru. This added significantly to project costs and schedule. Nevertheless, the ponds were excavated and the materials disposed of within the PCA budget for four of the five villages, and additional funds were secured to address Dareta and Yarlgama. The heavy equipment was finally de-mobilized the week of February 20. Ponds were not cleaned at Abare pending resolution of the Sokoto Rima Dam issue.

Excavation Schedule by Village: The challenges offered by the various villages affected the schedule differently in each of the main task areas. The most challenging villages were Sunke and Tungar Daji due to the extent to which villagers were involved in processing, extensive contamination outside the compounds, and the use of waste material as fill in various locations throughout the villages.

Abare: Remediation in Abare proceeded with little problem due to the village's location near Anka. Characterization was complete the week of October 3. The landfill and clean soil placement occurred the following week. Initial remediation commenced in Abare the week of October 17 and compound and exterior excavation was completed the week of November 21. One remaining exterior processing area was excavated and the landfill was closed the week of January 23. Cement work was completed the week of November 21. It was subsequently discovered that Abare and the landfill may be inundated by a federal water project in the coming year. See discussion in Section III. C.2.11.

Tungar Guru: Characterization was completed the week of October 10, followed by the landfill and clean soil placement the next week. Remediation was completed by the week of November 21, on the same schedule as Abare. Cement work was completed the week of November 21. The landfill remained open to accommodate waste from one village pond and process area at Tungar Guru and 1 pond from Yarlgama that were cleaned the weeks of February 6 and 13. The landfill was closed the week of February 20, 2011.

Sunke: Sunke was the most contaminated and troublesome villages to remediate. The difficulties were largely due to the extensive amount of processing that occurred here and at Tungar Daji relative to the other villages. The excessive contamination required nearly twice as long per compound to characterize as other villages, and was not complete until the week of October 31. The initial landfill site had to be abandoned and relocated due to encountering groundwater at the first location. An amended excavation protocol was attempted at Sunke that resulted in significant over-excavation for a period of time. As a result, the landfill was undersized and required extension that was not completed until the week of November 14. The extent of exterior contamination was pervasive and unanticipated, extending both the construction schedule and generating large quantities of waste. Subsequently, it was discovered that ten ponds had been used for processing and required remediation. Extremely high lead levels and free mercury was encountered in several of these ponds, necessitating additional worker precautions. Accommodating the additional pond waste required a third extension to the landfill in the week of February 6 and the landfill was eventually closed the week of February 20. Cement work was completed the week of February 6.

Tungar Daji: Tungar Daji was also heavily engaged in processing and was contaminated to a similar degree to Sunke. The landfill was constructed and clean soil placed the week of October 31. Mapping and characterization, however, was extended through the week of November 14, as remediation was not scheduled to commence until work ended in Abare and Tungar Guru, freeing up equipment and supervisory personnel. Compound remediation proceeded with little difficulty and was largely complete by the holiday break. Seven remaining compounds were excavated following the break. However, the extent of exterior contamination was unanticipated and extended the schedule, as it was accomplished with hand labor. Ten ponds required excavation in Tungar Daji and the landfill capacity was exhausted by the week of January 23. Tungar Daji wastes were then trucked to the Duza landfill for disposal. Construction was completed and both landfills were closed the week of February 20. Cement work was completed the week of January 23.

Duza: The work in Duza paralleled the effort in Tungar Daji. The landfill construction and clean soil placement was completed on the heavy equipment schedule the week of October 31. Characterization was conducted the week of November 21 and remediation commenced the next week and was completed prior to the holiday break. Cement work was completed in conjunction with Tungar Daji the week of February 6. The landfill was closed the week of February 20.

Schedule Overview: The original schedule developed during the preceding rainy season proved to be unworkable and was amended in December 2010, and subsequently required another additional two weeks in February to complete. Several factors contributed to the impossibility of meeting the original schedule. Problems were associated with lack of characterization of the extent and severity of contamination and unknowns at the time the original schedule was developed. Three of these villages were neither visited nor characterized by remedial staff prior to developing the schedule and cost estimates. Other difficulties were associated with the political climate surrounding the upcoming national elections. Numerous challenges were confronted everyday associated with logistics in these remote locations, and the deplorable state of community and regional infrastructure. Several delays were associated with security and health and safety issues for international staff due to the limited effectiveness of health services and security personnel in the bush locations. Additional discussion is provided in Section III. C. 2.

Those more significant problems included:

- Lack of access to the villages due road damage and impassably high rivers that isolated some villages prior to late October.

- Protracted negotiations with ZMoE officials regarding compensation, equipment supply, and vehicles in September/October.

- Difficulties and delays in securing sufficient four-wheel drive vehicles to convey staff and workers.

- Difficulties and delays in procuring affordable rates for heavy equipment.

- Protocol modifications associated with sampling soils during the cholera epidemic in the villages.

- Illness among staff due to malaria, respiratory disease, heat stress and fatigue contracted in the villages.

- Unexpected degree and severity of contamination within compounds and extensive processing areas in Sunke and Tungar Daji.

- Unanticipated security lockdowns associated with local elections and armed robberies.

- Unanticipated drying and exposure of pond bottoms promoting extensive brick-making using contaminated wastes by villagers following an unusual level of compound damage during the rainy season.

III. B.3.2. Contaminated Soil and Waste Removals: Table A shows the collective remedial actions accomplished under both Phase 1 and Phase 2 activities; **Table D** summarizes the pre-remediation lead levels in soils for compound interiors.

A total of 282 compounds, 10,000 square meters of exterior areas, and 30 ponds were decontaminated. Before remediation, 39% of the compounds exceeded 5000 mg/kg. The post excavation checks required lead levels <400 mg/kg, a 92% reduction. These areas were then covered with a clean (<100 mg/kg lead) soil cap.

Table F shows the total waste quantities of soils removed from compounds, exteriors, ponds and process areas and the associated landfill capacities. The landfill capacities provide caps and protective covers. In total, more than 6800 cubic meters of waste was removed from the villages. The largest efforts were expended in Sunke and Tungar Daji where waste volumes exceeded preliminary design estimates based on the Phase 1 experience. **Table G** provides GPS coordinates for the villages and landfills as well as dates when landfills were opened and closed.

In all villages, the drying of ponds exposed ore washing waste and raw ores disposed of during the Emirate's enforcement campaign in April 2010. Removing this waste required re-mobilization of heavy equipment and expansion of landfills in Sunke and Dareta. In Tungar Daji, landfill capacity was exhausted by the degree of exterior contamination and the ponds, but available space in the nearby Duza landfill was able to accommodate the excess volume generated at Tungar Daji. In Yarlgama, excavated pond material was transported to the Tungar Guru landfill prior to closure of that facility. No pond removal occurred at Abare pending resolution of the landfill relocation.

III. B.3.3. Bagega Activities: The PCA was extended in December to begin implementation of remedial activities in Bagega. The extension generally outlined three goals reflecting the approach noted above in the schedule of activities for the five villages. The initial tasks include characterization, development of landfills and clean soil borrow areas, and initiation of remediation at high priority locations. The PCA also included a temporary measure to limit children's access to the mining village area by construction of a fence. Subsequent collaboration with MSF and local and State officials, combined with independent actions undertaken by the Anka Emirate and Bagega district authorities, led to a decision to eliminate both the fence and specific compound remediation. Instead, efforts were focused on supporting demolition of the mining village, accelerated removal of waste products from the Industrial Area, and completion of the characterization and design of the remedy.

These modifications were sought by MSF for both security and logistic considerations. In March, MSF will open clinics to initiate chelation treatment of the children in Tungar Daji and Duza. At that time, MSF will also establish a residential presence in the TG/BI compound at Bagega. However, MSF will not be able to offer chelation services to Bagega residents, other than to those exhibiting critically ill symptoms. Contamination is widespread in Bagega and exposures are pervasive from a number of sources. Experience in the seven villages indicates that effective exposure reductions can be only be achieved with a comprehensive approach of combined compound, exterior, pond, brick-making, and Industrial Area remediation. Spot remediation of individual compounds, although beneficial to compound residents, will not be sufficient to permit MSF to commence chelation for those individuals. MSF has requested that compound remediation be accomplished in coordination with the emergency based cases, and as specific efforts to facilitate acute trauma or life-saving treatment.

Implementation of select compound remediation,- without full assurances of prompt follow-up on the remaining compounds, exterior common areas, processing and Industrial Areas, and ponds, will create false expectations of treatment and employment. Frustration over these issues among Bagega residents may lead to lack of participation and support, compromising both the effectiveness of the program and the security of MSF and TG/BI personnel.

The original intent to fence the Industrial Area was to prevent children's access to the mining village. Since that time local officials have demolished the mining village, and required the miners to remove their equipment and stockpiled ores to alternate locations. Local governments have initiated a ban and enforcement program regarding processing in this area. The Emirate and civil authorities have begun to arrest, fine and jail miners who continue to process ores in the Industrial Area. The local village heads have admonished all visitors not to frequent this area until cleanup has been completed. This has greatly diminished the presence of children and villagers in the Industrial Area and the need for fencing. Local officials believe they can effectively limit access by young children to these areas through warnings and institutional constraints. There is concern that a fence would invite vandalism, scavenging, and provide a false sense that the site was dealt with and would not require remediation. As a result, the fence was deleted in favor of i) working collaboratively with MSF and ZMoH in addressing high priority removals for critically exposed children; ii) accelerated efforts to complete characterization and design, and iii) emphasizing transfer of skills, technologies, and responsibilities to State, local and Federal authorities.

Characterization and design work has commenced following the USEPA *Engineering Evaluation and Cost Assessment (EECA)* guidance. The EECA approach was selected for Bagega because the procedures were developed to address sites with a higher level of preparation and detail than "emergency removals", but in an expedited manner in comparison to the level of scrutiny required for "remedial actions". The fundamental steps in an EECA are; i) Expedited Risk Assessment, ii) Focused Feasibility Study, ii) Preliminary Remedial Design, and iv) Feasibility Level Cost Estimates.

This process best applies to the Bagega situation because:

- Bagega has nearly as many compounds as the entire Phase 2 effort;

- the Industrial Area is a complex project requiring more sophisticated engineering, contractual and organizational resources;
- wastes were used for bricks, plaster and fill material in compounds, requiring consideration of building and wall demolition;
- the reservoir may need to be drained to be fully remediated; and
- waste segregation and several landfills may be required.

The magnitude and complexity of addressing these additional challenges is beyond those encountered in the previous villages. Remediation of Bagega exceeds the available funding by more than twenty times. As a result, the following tasks were undertaken with the current PCA funds.

III. B.3.4. Bagega Remedial Design Tasks Completed: The following tasks were undertaken and completed for Bagega.

1. Mapping of Village
2. Mapping of Exterior Common Areas
3. Survey Questionnaire of Village
4. Construction Survey of the Industrial Area
5. Development of an International Staff Compound
6. Accommodations Established for National Staff
7. Development of the Village Remediation Plan
8. Development of the Industrial Area Remediation Plan
9. Specification of Equipment and Supplies
10. Landfill Design
11. Identification of Landfill Location and Clean Soil Source
12. Construction of the Initial Landfill
13. Development of the Soil Staging Plan
14. Sampling of 124 Compounds
15. Sampling of 28 Exterior Areas
16. Sampling and Professional Survey of the Industrial Area

The following Deliverables will be provided to the new ZMoE, Department of Environmental Sanitation to undertake the remediation when requisite funding has been secured.

1. Risk Assessment and Mitigation Summary
2. Revised Project Control and Protocol Documents
3. Village Remediation Design Documents
4. Industrial Area Remediation Plan
5. Landfill Design Documents

Bagega Village: The survey questionnaire results indicate:

- 380 Compounds Identified in Mapping
- 370 Targeted for Survey
- 346 Attempted Contacts
- 313 Responses (85% of mapped compounds)
- 192 Admitted or Suspected Processing (61% of responses)
- 227 Require Remediation (61% of 380 identified)
- 270 Budget Estimate for Remediation (20% contingency)

Figure 9 shows Bagega divided into quadrants to facilitate testing and remediation. **Table H** summarizes test results for the compounds sampled in the four quadrants. Examination of **Table H** shows that contamination is more extensive than indicated in the responses to the questionnaire . In total, 92% of compounds (or 340 residences) will require remediation (as opposed to 61% estimated from respondents to the survey). Eighty-three (83%) of compounds will require excavation; this value is similar to the percentage remediated in the five CERF villages. However, (47% of compounds tested show maximum lead concentrations exceeding 5000 mg/kg, as compared to 39% in the five villages, indicating the Bagega compounds are generally more contaminated.

In addition, the use of waste ores in compounds for bricks, plaster and fill for road bed is more pervasive than the other villages. Testing shows 14% of compounds tested are constructed with bricks, and 11% of compounds have plaster exceeding 2000 mg/kg. Seventeen percent (17%) of compounds are backfilled with ore sand typically ranging from 20,000 mg/kg to 40,000 mg/kg lead. High mercury concentrations are common in these sands. Eighty percent (80%) of exterior areas tested show lead concentrations exceeding 5000 mg/kg.

These factors indicate that substantially more removal will be required in both Bagega compounds and exterior areas than was evident in the five villages. Additionally, removal of sand fill, bricks and plaster will require development and implementation of new protocols and considerable expense.

Bagega Industrial Area: The Bagega Industrial Area has been sampled and a professional surveyed conducted. **Figures 9** and **10** show the survey base map and attended sample results. The Industrial Area was divided into sub-areas based on projected remedial action required as indicated in Table I. The total contaminated area is estimated at 50,000 square meters. The nominal waste volume is approximately 15,000 - 20,000 cubic meters, which will require substantial additional landfill space to accommodate. Approximately 9000 cubic meters of waste were disposed of in Phase 1 and 2 removals. A similar quantity is expected from Bagega, indicating a total landfill requirement of 30,000 cubic meters.

These wastes are located largely in the seven areas designated as Areas A through G that show average surface soil lead levels 25,000 mg/kg to 50,000 mg/kg (2.5 – 5%). Table I also shows typical concentrations for specific use sub-areas within and adjacent to the larger Industrial Area. Residual ore piles typically range from 4-5% lead and sluicing areas and the reservoir beach are generally 1-2% lead. Typical excavation depths are .05-0.1 meters in Areas A, E and F; and 0.5-1.0 meters in the other areas. The former grinding areas and the adjacent large flat area show concentrations near 1% lead. The nearby Mosque, farming and wooded areas generally show concentrations less than 1000 mg/kg excepting locations where ores were dumped.

The adjacent reservoir was heavily utilized for washing and sluicing of ores and is highly contaminated with lead levels averaging 1-2%, at least, near the shore. Historic aerial photos show that the water level recedes significantly by the end of the dry season in May. It would be advisable to conduct additional testing and assess the feasibility of removing wastes from the perimeter area during the low water period.

Remediation of the Industrial Area is a higher level project requiring significantly more use of heavy equipment and strategic sequencing of construction activities. It is recommended that a design and specification bid package be developed for the Industrial Area project. Solicitation of a resident engineer and construction contractor to undertake this work under the oversight of ZMoE, assisted by an experienced international advisor, is recommended.

III. B. 4. Remedial Effectiveness

The effectiveness of the remedial efforts can be assessed by the percent completion of projected activities, overall reduction of soil-based exposure to village residents, the number and percentage of the target childhood population to be afforded treatment, and the capacity of local and State institutions to undertake future cleanups.

III. B.4.1. Completion of Projected Activities: All projected activities have been completed. Characterization of surface soil contamination was completed in the five villages by the week of November 21, 2010 (**See Table E**). All contaminated compounds, exterior areas, process areas, and ponds have been remediated in all five villages. All surface soils exceeding 1000 mg/kg lead were excavated and disposed of in local landfills. Clean soil covers were installed in all excavated locations and any soils demonstrating lead levels between 400 mg/kg and 1000 mg/kg lead. The landfills in the five villages and in Dareta and Yarlgama have been closed (See **Table G** for precise locations and dates).

III. B.4.2. Reduction in Soil-based Exposures: Soil lead exposures in contaminated compounds and common areas have been reduced by more than 95% from typical pre-remedial soil lead concentrations ranging from 5,000 mg/kg to >10,000 mg/kg to clean soil surfaces <100 mg/kg. Processing areas within the villages have been remediated to similar standards and village authorities are prohibiting continued processing in these locations. Contaminated ponds used for brick-making were drained, contaminated muck removed and wastes disposed at the landfills, eliminating this dangerous source of re-contamination. There has been some evidence of re-contamination within compounds where individuals have elected to return to mining that is being addressed by local authorities.

III. B.4.3. Population Afforded Treatment: All children five years old and under – nearly 2000 children - are now eligible for chelation therapy. MSF has opened clinics in five of the seven villages (the last two clinics should open in March 2011). As shown in **Table C**, through January 2011, nearly 1466 children were estimated to be $\leq$5 years old in those 5 communities; 1284 (88%) of these were screened with 926 (63%) entering the chelation program. Of those tested, 74% had blood lead levels $\geq$ 45 ug/dl.

Figure 8 shows blood lead reductions achieved in Dareta and Yarlgama, where chelation therapy has been underway since remediation was completed in June/July 2010. Average blood leads have decreased by more than 50% from >140 ug/dl to near 65 ug/dl.

III. B.4.4. Capacity for State Assumption of Remedial Activities:

This project has been a collaborative effort to assist and simultaneously develop technical and management capacity within the staff and senior management of ZMoE. In both Phase I and 2, the TG/BI role has been to provide advice and recommendations to the ZMoE regarding methods and procedures to assure sound environmental and health practices are employed. These methods are adapted from US experience, with TG/BI working with the ZMoE in an advisory and oversight role. TG/BI has conducted on-site sampling and has worked with the ZMoE, ZMoH, MSF, WHO and CDC to specify these recommendations in accordance with Zamfara State practices. This advice is provided to incorporate procedures and practices into the construction activities and provide appropriate oversight. TG/BI has maintained on-site presence during the construction period for the convenience of the Ministry.

The ultimate goal of this assistance is to develop the capacity for Nigerian institutions to assume the remediation program, establish safe mining and processing practices, and regulate the artisanal mining. In that regard, the project has downloaded responsibilities to the ZMoE staff at every opportunity. There have been marked successes in field activities, management of on-scene personnel, and payroll responsibilities. However, additional training, on-site project management experience, and responsible fiscal procedures and budget controls will be required before senior management will be capable of undertaking projects of this complexity. It is recommended that project design and management be contracted under ZMoE oversight to experienced international or Nigerian consultants with access to the appropriate technical skills, capabilities and budget and fiscal controls. See Sections III. C.2. and III. E. for additional discussion.

III. C. IMPLEMENTATION CONSTRAINTS AND LESSONS LEARNED

III. C.1. Unprecedented Effort

Never before has there been a lead poisoning epidemic of this magnitude anywhere in the world. The project was initiated in a triage situation in which patients were dying of lead poisoning each day. In addition, these villages were in remote locations with limited access and deplorable infrastructure, and little or no health care facilities. The villages were isolated and engaged in conservative social and religious practices that exacerbated exposures and morbidity. On-going exposure and blood lead absorption levels were higher than any known in the international literature. The principal routes of exposure were contaminated soils and dusts in communities where nearly all homes and structures made of mud. For many of the residents no relief from these exposures was available.

Moreover, there was a universal lack of international experience and cleanup models to address these types of situations. In the preceding three years, the TG/BI principals in this effort had undertaken smaller pilot cleanup projects in Senegal, the Russian Far East, and the Dominican Republic. Few other remediation of communities experiencing these levels of exposure in undeveloped nations was known, had been attempted, or reported.

Nevertheless, in three weeks in collaboration with multiple entities, a remediation protocol was developed and implemented in a manner consistent with village social and technical capabilities. Greater than 95% reductions in soil lead exposure were achieved and treatment initiated for more than 400 children in both clinical and out-patient facilities.

In accomplishing these ends, tremendous health, environmental, technical, engineering, cultural, capacity, political, logistical, safety, funding and implementation challenges were met and addressed through collaborative efforts of numerous entities. Unfortunately, the cleanup was curtailed by the rainy season from mid-July to October 2010. During the interim, this PCA and other funding were secured to continue cleanup in five additional villages and prepare for the massive effort required in Bagega. There was no time, opportunity or funding available to characterize these villages, or modify the fundamental approach to remediation developed for the Phase 1 cleanup. As a result, numerous other challenges and unanticipated problems were encountered in Phase 2 operations. These unforeseen and uncontrollable developments extended the schedule and required innovative techniques to overcome. However, again through the collaborative efforts of multiple partners, these problems were addressed and remediation of the five villages and characterization and design of the Bagega cleanup was completed.

III. C. 2. Problems Encountered

III. C.2.1. Capacity in State and Local Institutions*:* State and local governments do not have the capability or resources to undertake a remediation program. The magnitude of this epidemic would challenge any state or local environmental regulatory agency in developed countries. In Zamfara, the governments have little practical experience and limited expertise with regard to pollution control, beyond basic sanitation programs. Coupled with the remote location, lack of functional infrastructure and resources, and extreme poverty and illiteracy in these villages, Zamfara and LGA agencies were overwhelmed. Over the past eight months, considerable progress has been made in developing the field capabilities and technical expertise of ZMoE and LGA staff. The mid-level staff of ZMoE have been actively employed in the daily remediation activities, and have progressively assumed increasing levels of responsibility. Appropriately supported, the staff could likely organize, manage and supervise village labor with limited oversight. The upper management levels have not been actively engaged beyond supplying vehicles, staff, and limited administrative support activities. Senior management is likely not able to provide sufficient technical direction, and responsible fiscal management would be a substantial challenge. International or experienced and responsible Nigerian construction engineers should be retained to provide Project Management for future tasks.

III. C.2.2. Socio-economic Status of the Villages

Housing: A review of the 2006 Nigerian census data reveals some of the challenges regarding efforts to sustain the environmental remediation and to explain the dangers of ore processing in residential compounds. **Table J** shows the characteristics of housing in Nigeria, Zamfara and the Anka and Bukkuyum LGAs. Housing in Anka and Bukkuyum LGAs consists of 41% and 39%, respectively, traditional hut, nearly 3 times the percentage of traditional huts in the whole of Nigeria. The housing in the 7 villages in this project is nearly 100% traditional, with earth/mud flooring, roofs and walls. These materials frequently collapse during the rainy season and continually erode throughout the year. Because compounds were built from contaminated soils a long-term institutional control to ensure that contaminated bricks are removed from the villages, upon collapse and replaced with clean materials should be developed. The remedy could be developed similar to lead paint abatement in the US where leaded paint has been gradually removed from public housing over decades as resources allowed.

Water and Electricity: **Table K** reveals the LGAs' access to wells, electricity and television. In Anka and Bukkuyum LGAs, 59% and 48%, respectively, use wells for their domestic supply of water. Many of these are common public wells and experience in the villages shows some of them to be contaminated with metals, and though not tested, undoubtedly are high in bacterial contamination. Home hygiene is particularly challenging as buckets are used to transport the water into the compounds for use in cooking in bathing. Washing a child in a compound with a dirt floor reinforces the need for the metals contamination in the soil to be removed. In Anka and Bukkuyum LGAs, 6% and 7% of the population, respectively has access to electricity and 74% and 62%, respectively have no access to television. (Some public "television theatres" do exist in some of the remote villages).

Literacy: Most striking is the lack of literacy and basic education in Zamfara state (data for the LGAs were not available although many of the villages have no schools). As shown in **Table L**, In the whole of Zamfara, which includes the urban areas of the state capital, Gusau, 61% of the population has never attended any school and 51% is not literate, as compared to 32% and 33%, respectively, for Nigeria. The rates for females are notably lower than for males, revealing the difficulties in educating mothers to the dangers of lead poisoning through traditional means (pamphlets etc.).

III. C. 2.3. Suitable Heavy Equipment, Support Vehicles: Little heavy equipment is available for lease in Zamfara. Only the large mining concerns seem to have appropriate equipment that is maintained and reliable. This equipment is expensive to lease, and is obtainable only at rates expected for high-income countries. Heavy equipment, including small and medium-sized lorries consumed 38% of the budget expended in country. Due to these challenges and resource demands, heavy equipment was operated on an independent schedule from those tasks emphasizing hand labor, as down times due to overall scheduling are hugely inefficient when applied to heavy equipment. The ZMoE does not have the capacity to manage or budget heavy equipment for routine construction tasks and scheduling. A professional construction manager should be retained for future work, either from international or Nigerian industry sources, to manage the heavy equipment procurement, operation scheduling and contracts.

Support vehicles are even more difficult to obtain, as these must be 4-wheel drive and subjected to rugged conditions. Leasing 4-wheel drive vehicles is more expensive in northern Nigeria than in high-income countries. Several vehicles were obtained from the State, LGA and Emirate to support the project. Under the arrangement the project paid for drivers, fuel, and repairs. The vehicles constantly needed attention, and some drivers were undependable and required close supervision. A significant portion of senior management time was devoted to vehicle acquisition, scheduling and maintenance. Private rentals are extremely expensive, at rates several times that of developed countries. Vehicle agreements should be negotiated with government sources as in-kind contribution in future efforts. A logistician position should be identified to supervise vehicle activities.

III. C. 2.4. Fuel and Supplies: Adequate supplies were obtainable with the assistance of, and through MSF, logisticians. This project would have been more difficult and costly, and much less successful, without the experience and assistance of MSF logisticians. Nigerian sources were less dependable and there were considerable problems with delivery schedules, quality of goods, and operating in a cash only market. Some progress was made late in the project in securing dependable vendors who would accept bank drafts. Fuel for the heavy equipment was problematic, as deliveries were sometimes diluted with water or kerosene and equipment had to be fueled daily to avoid theft. Drivers had to be accompanied to filling stations to assure that the vehicles were appropriately fueled. There is limited incentive for preventive maintenance. These problems could be effectively addressed by a dedicated logistician position.

III. C. 2.5. Zamfara Contractor Capacity and Reliability: Use of local contractors to supply heavy equipment and fuel was attempted with little success. Deliveries were not timely and the equipment was generally aged, unmaintained, in poor condition, and unreliable. Advance payment generally exacerbated the situation, resulting in delivery of equipment that broke down within a few hours or days, resulting in critical delays and demands for supplemental payments. Dependable equipment had to be obtained from several hundred kilometers away in Sokoto or Kaduna, and usually at inflated rates.

III. C. 2.6. Underfunding: The project was not sufficiently funded from the beginning. In addition, the initial cost estimates were based on limited data and experience with conducting emergency removal activities under the difficult conditions found in these villages, and the resources available in Zamfara. UNICEF/BI provided slightly more than $850,000 of the initial US $1.2M estimated costs for the five villages in late August. In September, additional project funds were requested from the State government to provide heavy equipment leases, support vehicles, and Senior Management salaries. State funding was released to the support the cleanup project in early October. However, assistance was not forthcoming for either heavy equipment or Senior Management. The State and LGAs did provide vehicles and per diem support for their staff and the Anka Emirate provided two vehicles and security. The project ultimately paid allowances to three Senior Management personnel to obtain staff and vehicles. The cleanup project was delayed by 2-3 weeks to negotiate these arrangements and secure the vehicles. Budget shortfalls were eventually accommodated through provision of in-kind services by TG and cash contributions by MSF.

III. C. 2.7. Delays beyond Project Control: Significant project down time was experienced due to weather; including rain, swollen rivers, and Harmatan winds; equipment procurement and vehicle breakdowns; road and bridge conditions; and health and security concerns. Health and safety related delays were due to two primary factors – illness and security lockdowns.

III. C. 2.8. Illness and Disease: Because of the emergency situation, a 12 hour, 6 day work week schedule was maintained, which often extended into Sundays for senior personnel. An eight day holiday rest spent in Abuja in late December 2010 was the first break since September for a number of team members. This rigorous schedule doubtless contributed to fatigue and illness among both the international and national staff. Over half of the TG/BI staff contracted malaria during the course of the Project, in spite of and mitigated in severity by the use of prophylactics (Malarone). Severe bronchitis and sinus problems (due to dust especially during the Harmatan season) and food poisoning also plagued the team. Similar problems were noted with national staff, as well. Other diseases noted by MSF in the villages that were successfully avoided included typhoid, cholera, measles, and meningitis.

From September to November the project was conducted in the midst of an ongoing cholera epidemic. More than 200 children were being simultaneously treated for lead poisoning and cholera in the MSF hospital. Cholera is endemic in the compounds where soil sampling, characterization and remediation were ongoing. Open defecation by young children is commonplace within the village, requiring extraordinary precautions to avoid exposure while implementing these tasks. Due to these threats, physical safety hazards, and the need to stage work from remote compounds developed in the bush; this project would have been impossible without the advice, medical and logistic services, and cooperation extended to TG/BI staff by MSF.

III. C. 2.9. Robberies and Political Unrest: Due to political unrest, election activities and numerous armed robberies on the roads, TG/BI followed MSF policies in declaring compound lockdowns. During one primary election week in January 2011, no one left the compound for one week and remediation work in the villages was suspended completely. Other lockdowns ranged from several hours to 1-2 days. Frequent, almost daily, vehicle breakdowns also plagued the team throughout the project. The potential for armed robbery precluded travel to and from Bagega, Tungar Daji , and Duza on market days. The TG/BI payroll process was an especially troublesome endeavor. The use of village labor required that workers be paid on a regular basis in the villages. This, in turn, required transporting large sums of cash over dangerous and unpredictable roads on a weekly basis. Invaluable assistance was secured from the Emirates, local police and the LGAs in acquiring the cash from TG/BI representatives in the bank, developing the pay packets, and delivering the payroll to the villages under armed escort. This procedure negated the need for international personnel to handle large sums of cash outside of the bank, and lent the community's trust in the Emirate to the payment process.

III. C. 2.10. Road Conditions and Travel Time: The poor quality of the roads was a daunting challenge. Unpaved roads were unsuitable for the heavy equipment, due to the size and weight and had to be repaired on the move. Long travel times were common for the international Technical Advisors, ZMoE and LGA managers. Although remediation had to be terminated during the peak rainy season (July – August), during the weeks before and after that period travel times were up to four times longer than in the drier months. Even in the best of conditions the 30 km trip from Anka to Bagega took more than an hour, due to the poor condition of the roads. Safety protocols that precluded pre-dawn travel and required returning to base (in Anka or Bagega) before nightfall, constrained productive working hours in distant villages. During security alerts (due to political unrest or recent road robberies), travel time increased with precautions such as not being the first vehicle on the road and waiting for oncoming traffic (whether by car, motorcycle, bicycle or camel) to verify the way was clear.

III. C. 2.11. Sokoto Rima Dam Project: This major water resource project is being sponsored by the federal government and is has been under consideration for nearly five years. The design was complete about 18 months ago and funding was approved on December 11, 2010, after the remediation was completed in Abare. Work on road improvements, site preparation and geological investigations began during the week of January 16. Each project became aware of the other only in late January following the holiday break. Review of the plans for the dam and reservoir show that the landfill is located within the reservoir near the proposed spillway location. All of the parties involved agree, if the dam project goes forward, the landfill should be relocated. A landfill containing all the waste from Abare lead poisoning incident should not be allowed in the reservoir. However, there are no remediation funds available to move the landfill.

His Excellency the Governor of Zamfara has instructed the Secretary General of Zamfara State to convene a meeting between the ZMoE, the dam project Contractor, and TG/BI to discuss the situation further. The aim of the meeting is to arrange for the Contractor to undertake re-location of the landfill as part of the dam project. The work would be conducted under the direction and specification of the ZMoE, with TG/ BI providing technical guidance to the Ministry for design, implementation and oversight. This is conditioned on the project being undertaken while TG/BI has appropriate technical staff in the Country.

III. C. 2.12. Ponds and Brick Making: Following the holiday break it was discovered that village ponds were drying up. It was revealed that some ponds had been used for both washing and ore disposal. Several ore bags were thrown into ponds when the Emir issued the mining ban in March and April 2010. Village residents were using the materials in the ponds to make bricks to build and re-build compound walls. This created an immediate and severe threat of recontamination. The pond mud is highly contaminated (up to 70,000 mg/kg or 7% lead). Many of the bricks are highly contaminated (1000 - 40,000 mg/kg lead) and would deteriorate to eventually re-contaminate the compounds. Current exposures were observed as children (8-10 years old) were often doing the doing the work, with younger siblings attending. Additionally, the brick makers are doubtlessly tracking contamination back to the compounds.

These ponds have been a challenge throughout the project. Cleaning sediment and muck from the ponds when full of water is a difficult and dangerous task. The ponds were sampled in October 2010 by OCHA and were considered a lower priority risk, as long as people were not drinking from them and children were not accessing the muck. Alternate clean water sources are available in the villages and the pond edges were cleaned to the waterline in the initial remediation. Originally, remediation of ponds and water sources was deferred to later Phases of remediation. However, the drying of these ponds demanded immediate attention that required remobilization of heavy equipment and expansion of some landfills.

On January 29, 2011 a memo concerning pond and brick making was forwarded to the Governor of Zamfara. His Excellency approved of the suggested course of action and recommended that the Emir be approached regarding enforcing a ban on using bricks made from these ponds. The following emergency protocol was implemented:

i) Village heads were contacted to temporarily suspend brick making.

ii) Existing bricks were tested and either condemned or released for use.
iii) A pond assessment protocol was developed and applied.
iv) A remediation protocol requiring use of heavy equipment was developed.
v) A remediation protocol for ponds using hand labor was developed.
vi) Quantity estimates were developed to expand the landfills.

Metal concentrations in Sunke pond mud ranged from 800 to >30,000 mg/kg lead and up to 2000 mg/kg mercury, with the majority of readings in the 1000 mg/kg to 5000 mg/kg lead range. In Dareta, pond mud contaminant concentrations ranged from 1000 to 70,000 mg/kg lead and up to 125 mg/kg mercury. Bricks made from the pond mud had contaminant concentrations ranging from 1000 to 40,000 mg/kg lead and up to 100 mg/kg mercury. Similar levels were noted in Tungar Daji and Yarlgama.

Pond cleanup was completed in Sunke, Dareta, Tungar Daji, Duza, Yarlgama and Tungar Guru by the end of February. The ponds in Abare were not addressed pending resolution of the Sokoto Rima Dam issue.

III. D KEY PARTNERSHIPS AND INTER-AGENCY COLLABORATION

This Project is a collaboration of the Nigerian Federal Ministries of Environment and Health; the Zamfara State Ministries of Environment and Health (ZMoE, ZMoH), the Anka and Bukkuyum Emirates and LGAs, international NGOs Blacksmith Institute (BI) and Medecins Sans Frontiers (MSF); US consulting firm TerraGraphics Environmental Engineering (TG); the University of Idaho (UI), multilateral organizations UNICEF, UNEP-OCHA, World Health Organization (WHO) and the United States and Nigerian Centers for Disease Control (CDC).

Chronologically, the lead poisoning epidemic was initially detected by MSF in April/May 2010, during the course of infectious disease immunization programs being implemented in Yargalma and Dareta villages. MSF informed the Zamfara and federal Nigerian Ministries of Health. The health authorities requested assistance from the US CDC, the Nigerian CDC and WHO. In May 2010, the CDC dispatched an investigation team to Zamfara accompanied by TG personnel as advisors regarding potential remediation. BI provided logistic support and equipment for the CDC/TG mission.

CDC, CDC-Nigeria, ZMoH, WHO and TG collaborated on combined health / environmental assessment of the two villages during late May 2010. During that time a diagnosis of lead poisoning was confirmed by the clinical experts, and soil and wastes contamination within the villages was characterized. Residual waste and soil contamination in the compounds of ill and dying children was identified as the principal exposure pathway. Subsequently, the Governor of Zamfara requested that TG/BI develop a remediation plan for the villages to compliment the treatment protocols being developed by the health authorities.

TG and ZMoE developed the protocol and assisted ZMoE in implementing the remedial strategy and cleanup in early June. BI provided fundraising, logistic and equipment support for the Phase 1effort. Phase 1 remedial activities in Yargalma and Dareta were funded by Zamfara State, TG, BI and MSF and were completed in early July. Cost estimates for the five villages in Phase 2 were developed by TG in late June and were submitted to CERF in July 2010. Eventually, the PCA between BI and UNICEF was negotiated to implement the Phase 2 cleanup. The Phase 2 activities were implemented in late September as a collaborative ZMoE, TG/BI undertaking funded by UNICEF. Simultaneously, several allied activities were underway in the overall response program. Among those related to remediation efforts in the villages, UNEP-OCHA and the National Water Resources Institute (NWRI) undertook a water quality assessment in the villages; MSF instituted out-patient clinical treatment; ZMoH, WHO and the federal Ministry of Health embarked on a program to enhance medical response capabilities; CDC assessed environmental contamination and childhood lead poisoning in nearly thirty other villages in Zamfara; and UNICEF collaborated with the same agencies and local LGAs in health advocacy.

With specific regard to the remediation effort, MSF assisted TG/BI in establishing staging compounds in Anka and Bagega, and hosted TG/BI in Bukkuyum. The LGAs provided housing and support for national staff, and the Emirates, LGAs and ZMoE provided vehicles. The project was implemented by ZMoE with the technical assistance of TG/BI. Funding was provided by UNICEF, TG, BI and MSF and disbursed through BI in Anka and New York. The Anka Emirate assisted in securing and disbursing local payrolls in the villages. TG, LGA, Emirate and village leaders collaborated on local female and male advocacy programs to solicit cooperation with remedial activities.

TG/BI acted in an advisory role to ZMoE in designing and implementing the remediation and decontamination activities. Remediation was conducted under the technical supervision of TG and administrative support of BI. The ZMoE certified the work. ZMoE provided senior management staff including the Permanent Secretary, Project Manager, Assistant Project Manager, and Field Managers. The LGAs provided Field Supervisors, and the villages provided laborers. A total of 19 TG/BI staff, 50 ZMoE and LGA personnel, and 250 village laborers participated in the course of the Phase 2 remedial activities. TG/BI and ZMoE staff collaborated with LGA, Emirate, and Village leaders to determine the extent of the contamination in Bagega, including the Industrial Site, and to develop best practices for artisanal mining and processing activities to prevent recontamination.

III. E. OTHER HIGHLIGHTS AND CROSS-CUTTING ISSUES

III. E. 1. Sustainability

Prevention of recontamination and return to the previous, or other, dangerous mining practices remains the single greatest challenge to this project. The poverty, remoteness, and lack of resources in these villages combine to limit villagers' and village heads' attention to immediate issues of economics and survival. The trauma of the lead poisoning epidemic and the enthusiasm generated by the remediation and treatment programs will fade and be replaced by the realities of making a living in these harsh conditions. Artisanal gold mining offers potential employment, income levels, and opportunity to improve village, compound, and family quality of life that is unavailable in other work sectors. The global increases in the price of gold, the increasing availability of international markets, combined with the ingenuity of Nigerian and local entrepreneurs and villagers will continue to expand and intensify these operations.

The federal ban on mining will eventually be lifted, or ignored. Any State program regulating processing based on enforcement will likely succeed, at best, in driving the operation underground. An enforcement based system would be difficult to implement and police in these remote areas; and be subject to abuse, fraud, and neglect. A regulatory system based on incentives and support of the industry, and one aimed at generating jobs and opportunities for villagers, rather than middle-men or foreign industries, would be most effective at sustaining the gains made in the cleanup and preventing future contamination within the villages.

III. E. 2. Governmental Capacity

Implementing and delivering any regulatory program or control mechanisms to extend the cleanup and control future artisanal mining in these villages will, necessarily, be a combined effort of the federal, State, LGA and traditional governments, and the villages. The experience of the remediation project with the current governmental structure suggests that the State is the critical path element in extending and sustaining the positive effects of the cleanup activities. These villages are extremely remote from Abuja, and there seems to be little federal involvement in either supporting or implementing the cleanups, or in regulating the dangerous activities at the village or LGA level. The LGAs seem to be in the best position to deliver governmental and social welfare services to the villages, and the Emirates are most effective in providing information and soliciting cooperation and compliance. Finally, the success of any future programs depends on acceptance and implementation at the village level, endorsed by the village chiefs, and accepted by the villagers.

All of these mechanisms are in place and were employed in implementing the cleanup activities in the villages, including the economic incentive of providing jobs for villagers. As a result, the level of cooperation achieved at the village level was extraordinary and was one area where few difficulties were encountered; and any problems that did occur were quickly resolved. Lacking was the technical capacity, project management experience, and funding necessary to design and implement the cleanup activities. During the Phase I and II cleanups, these capabilities were provided by TG/BI and the funding agencies.

It would be most effective to utilize these same delivery mechanisms in extending and sustaining the cleanup, and in developing and implementing safe mining practices. However, missing from the elements necessary to effectively implement such a strategy are the same key elements - technical capacity, project management experience, and funding. The ZMoE has the best prognosis for being able to develop and maintain the requisite level of technical expertise. There has been considerable success in developing staff level technical capacity at the ZMoE and LGAs. However, there has been limited engagement by senior management personnel in Phase 2 day-to-day project or fiscal management. It is unlikely that senior management could assume these responsibilities effectively at this time. Additional formal and on-the-job training will be necessary. This will be problematic for this project, as senior personnel are reluctant to work overnight away from home, and are generally absent in the evenings and mornings when key project problems are addressed.

In addition, there is a significant lack of credibility among workers, suppliers and contractors regarding the efficacy of governmental fiscal management. Numerous problems were encountered with budget management in Phase I under State control. The project was shut down and delayed several times due to lack of timely funding and complaints regarding unpaid bills and salaries, inefficient use and non-delivery on contracts, sub-standard supplies and equipment, and missing inventories. Whether these problems occurred, in fact, is unknown. Nevertheless, the acrimony resulted in delays and inefficiencies. There seems to be a general distrust in government that extends from the LGAs to the federal level, excepting the Emirates that are widely respected. Labor and contractual problems and inefficiencies were avoided in Phase II by paying bills in a timely and complete fashion.

As a result, it would be advisable to employ a consultant/contractual model to extend the cleanups and develop and implement an incentive-based regulatory program. The consultant should represent and report the State, but be accountable to strict fiscal and performance standards with independent oversight from the funding authority. Specifically providing effective training and engaging experience to senior and upper level ZMoE personnel should be a pre-requisite and priority objective of the program.

III. C. 3. Project Evolution (Magnitude and Issues in Bagega)

Section III. B. 1.1 discusses the basic US response model employed to date in Zamfara. Phase 1 and 2 should be regarded as “emergency removals” in USEPA vernacular. Failure to appreciate the approach level underlies the professional disagreements between TG/BI and the international auditors retained by UNICEF in November 2010. (See Auditors’ Report and TG/BI response).

At this point the overall project, the ZMoE is sufficiently experienced to integrate the more comprehensive "Engineering Evaluation and Cost Analysis (EECA)". Similarly, the magnitude and complexities of the situation in Bagega demand a more sophisticated and rigorous approach. However, in TG/BI's opinion, neither the ZMoE, nor the project, can accommodate the "remedial action" level advocated by the auditors at this time. Considerably more international resources would be required, the level of sophistication would impede technology transfer to Zamfara partners, and the associated cost and delays in achieving exposure reductions for the population would be unacceptable.

Sections III. B.3.3. and 3.4. discuss the issues and project accomplishments with regard to Bagega and the EECA approach. Undertaking the Bagega cleanup in an EECA format should be the first step in continuing to build capacity among the collective governments. This strategy should also integrate the associated pre-requisites to implementation and the responsibly to address these problems in the future.

Those pre-conditions to implementing remediation and treatment were proposed by MSF and TG/BI in late January. These were subsequently endorsed by ZMoE, WHO and UNICEF.

- Industrial Area Cleanup
    - Removal of secondary waste to remote re-processing location
    - Banning of further mining activity in area to be remediated
    - Completion of Remedial Design
    - Concurrence of appropriate Stakeholders
    - Approval of appropriate Government Authorities
- Mining Activities and Recontamination Control Plan
    - Identification of Responsible Authorities
    - Development and Adoption of Safe Practices
    - Concurrence of appropriate Government Authorities
    - Establish Appropriate Enforcement Procedures
- Funding Necessary to Complete Remediation
    - Funding of Remedial Design Activities
    - Funding and Completion of Industrial Area Cleanup
    - Funding of Village Cleanup
    - Concurrence of appropriate Stakeholders
    - Approval of appropriate Government Authorities

IV. FUTURE WORK PLAN

Future work will be required in two major categories and seven sub-areas. The first three sub-areas involve continued remediation including: i) Characterization and Inclusion of Additional Villages, ii) Bagega Village Remediation, and iii) Bagega Industrial Area Remediation. The remaining needs are Sustainability Issues including iv) Mining Processing Control, v) State Capacity Building, vi) Advocacy and Local Engagement, and vii) Remedial Effectiveness Evaluations.

All of the additional work is a continuation and extension of activities already underway to varying degrees. The work should be implemented through the new ZMoE – Department of Environmental Sanitation, the Emirates and villages. This agency has absorbed the ZMoE staff trained in utilized in the Phase 1 and 2 remedial actions. The ZMoE staff has been assuming increasing responsibility in implementing the remedy and is competent to proceed independently in certain tasks. Continued assistance from experienced international professionals and formal training and certification will be required to integrate more sophisticated skills and abilities into the agency. No funding is currently allocated to undertake either the training or the work, and it is hoped that support from the Nigerian federal government and State of Zamfara will be forthcoming to allow cleanup to continue.

IV. A CONTINUED REMEDIATION ISSUES

IV. A. 1 Characterization and Inclusion of Additional Villages

CDC (US and Nigeria) and ZMoH conducted scoping activities in Zamfara in October-November 2010 in order to identify additional villages that may be contaminated with lead. There were 114 villages identified to be processing ore in Anka, Bukkuyum and Maru LGAs. Of these, 73 villages were visited. 43 villages were identified to have children with BLL > 10 ug/dl and 27 villages had soil lead concentration of >400 mg/kg. The highest BLL measured among under-five children sampled was 60 ug/dl. These findings should be followed up on with both additional assessment of health risks and environmental characterization in these villages. The ZMoE Rapid Response team (RRT) and Department of Environmental Sanitation personnel have the capacity and training to undertake the environmental characterization, if provided with the necessary equipment (XRF, computer and dependable vehicles). Some international assistance would be required to assist in developing protocols, training individual assessors, and implementing database management capabilities. Estimated costs of characterizing and remediating these villages is likely on the order of US $50,000 per village, although no formal cost estimate has been prepared.

IV. A. 2. Bagega Village Remediation

Mapping of the Bagega is complete; about 1/3rd of village compounds and exterior areas have been sampled and the compound contamination maps prepared. Some individual compound residents are undertaking their own remediation, utilizing the project's compound remediation maps, and disposing of the contaminated soil in the project landfill. The ZMoE staff is capable of assuming both the completion of the compound and exterior sampling, and could implement compound and exterior cleanups. Adequate funding and support would be required including approximately US $600,000 - $800,000 for the compounds and hand-labor exterior areas, if implemented by national staff and local labor without international assistance or oversight. Additional equipment required includes XRFs, computers, printers and dependable vehicles. International oversight would be advisable for the initiation of activities and assumption of specific duties by the ZMoE staff. A specifically designed workshop carried out in Gusau for staff and advisors is recommended. Estimated cost for the village remediation, including heavy equipment utilization in exterior areas is US $1.6M, if conducted with international assistance in a model similar to the Phase 2 UNICEF action in the five villages. More precise funding requirements will be included in the engineer's design cost estimate provided to the ZMoE.

IV. A. 3 . Bagega Industrial Area Remediation

The Industrial Area cleanup design should be completed and developed into bid documents suitable for solicitation of a resident engineer and contractor to undertake the remediation under ZMoE oversight. International assistance would be advisable, as there is little experience among Nigerian firms in conducting this type of work; and the ZMoE has limited experience in contract oversight and administration. Formal training of ZMoE staff in US or European training programs is recommended. Preliminary cost estimates for this work with international assistance is US $400,000 -$600,000, exclusive of training and certification. More accurate funding needs will be included in the engineer's design cost estimate provided to the ZMoE.

IV. B. SUSTAINABILITY ISSUES

IV. B. 1. Mining / Processing Control

Development and implementation of safe and secure mining practices will be required to prevent the eventual reintroduction of processing into village compounds. In Bagega, there has been considerable progress accomplished through the establishment of the village *Lead Response Committee*. This group has worked with the miners to remove ores from the Industrial Area and establish a secondary leaching process in a location remote from the village. The local committee has worked with the Emirate and LGA to develop an ordinance to exclude mining from the Industrial Area pending the cleanup, and have arrested those found to engage in secondary processing in the excluded area. Efforts should be made to work with this group, the Zamfara Mining Association, and the ZMoE, Department of Environmental Sanitation to secure international expert advice. The advisor should assist the local miners in identifying and developing more efficient and safe mining practices, and in providing facilities for work site hygiene, security, and appropriate disposal of wastes. Currently there is no funding for these activities. Requests for proposals to provide such services should be developed jointly with the stakeholders in Bagega and extended to the other villages. Costs for providing outside expertise and developing a strategy for implementation is likely on the order of US $20,000-$40,000. Implementation and development of facilities would cost US $100,000-$200,000.

IV. B. 2. State Capacity Building

Several Sections in this report discuss the critical issue of developing governmental capacity to implement the remaining remediation activities, establish regulatory programs to control future processing and prevent recontamination, and assist the villages in developing a safe and productive mining industry. The experience of the last nine months has demonstrated that effective delivery, enforcement and avenues of cooperation are established in the LGAs and villages. These avenues have been effectively employed to implement a large and intrusive remedy with considerable good will and cooperation from local residents and village heads, despite the many logistical and resource challenges.

Lacking is the technical capacity, experience, project management and budgeting skills to implement the programs. The remediation effort of the last nine months has been carried out by less than 20 international advisors. Most of the management and supervision has been provided by the more than 50 ZMoE and LGA staff organizing and overseeing the daily activities or more than 200 villagers. The next Phase of cleanup implemented in Bagega should emphasize independent assumption of the planning and implementation of the daily activities by ZMoE staff. ZMoE should continue to use, support, and enhance the cooperative relationships and partnerships established with the LGAs, Emirates, and villagers.

More formal training, workshops and rigorous certifications will be required for senior management and upper mid-level managers to assume project and fiscal management responsibilities. These should be supported and provided by the international partners, and a continued international presence will likely be required to develop these skills, as has been evident in transferring technical capabilities to mid-levels mangers, supervisors and labourers over the past nine months. A modest budget for formal training should be developed for ZMoE, LGA and Emirate staff and Village leaders.

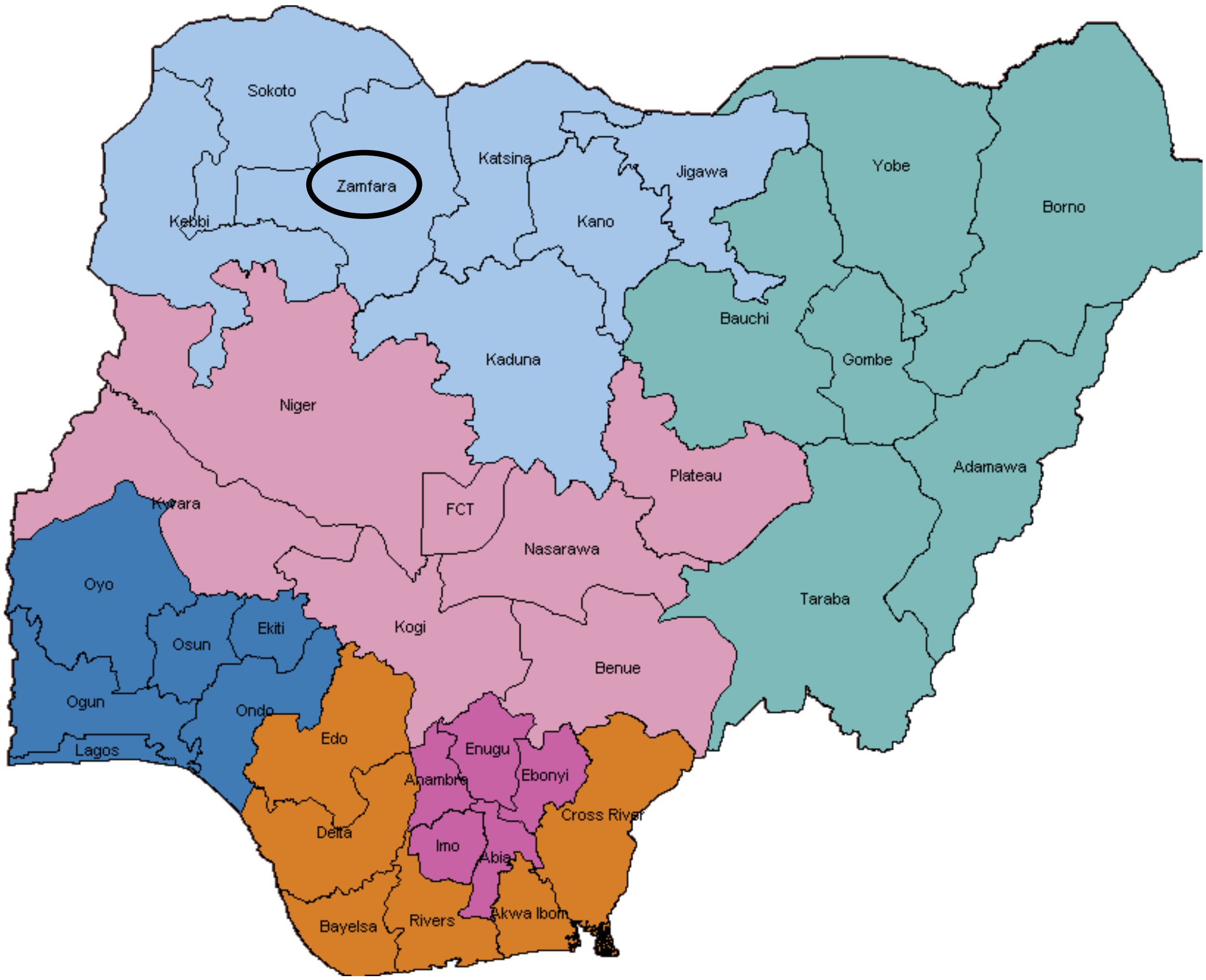
IV. B. 3. Advocacy and Local Engagement

Local advocacy efforts in the villages need to be continued and enhanced. There has been considerable success encountered utilizing the ZMoE Remediation Managers and LGA Supervisors in advocacy activities encouraging Bagega residents to relocate processing operations and restrict activity in the villages. This has been achieved by promoting a general awareness of the dangers of conducting these activities in the residences, and the advantages of operating in a specified location with attendant facilities to improve the efficiency and economics of the operations. Both male and female advocacy programs were initiated and delivered during the compound sampling activities. These efforts have induced several families to undertake self-remediation rather than wait for the project to secure funding. The advocacy efforts should be continued and enhanced during the Bagega village and Industrial Area cleanups. The costs of this program would be relatively minor, if attendant to and delivered with the remediation of the village and Industrial Area in Bagega. Funding, on the order of US $10,000-$20,000 could extend the program to other villages in the LGAs.

IV. B.4. Remedial Effectiveness Evaluations

A formal program of periodically assessing the effectiveness of the remediation process should be established and funded by the international partners. The program should periodically review progress in i) reducing blood lead levels among village children, ii) the sustainability of soil and dust lead levels, iii) status of the landfills, iv) mining and processing practices, and v) regulatory efforts to limit re-contamination and support safe mining and processing practices.

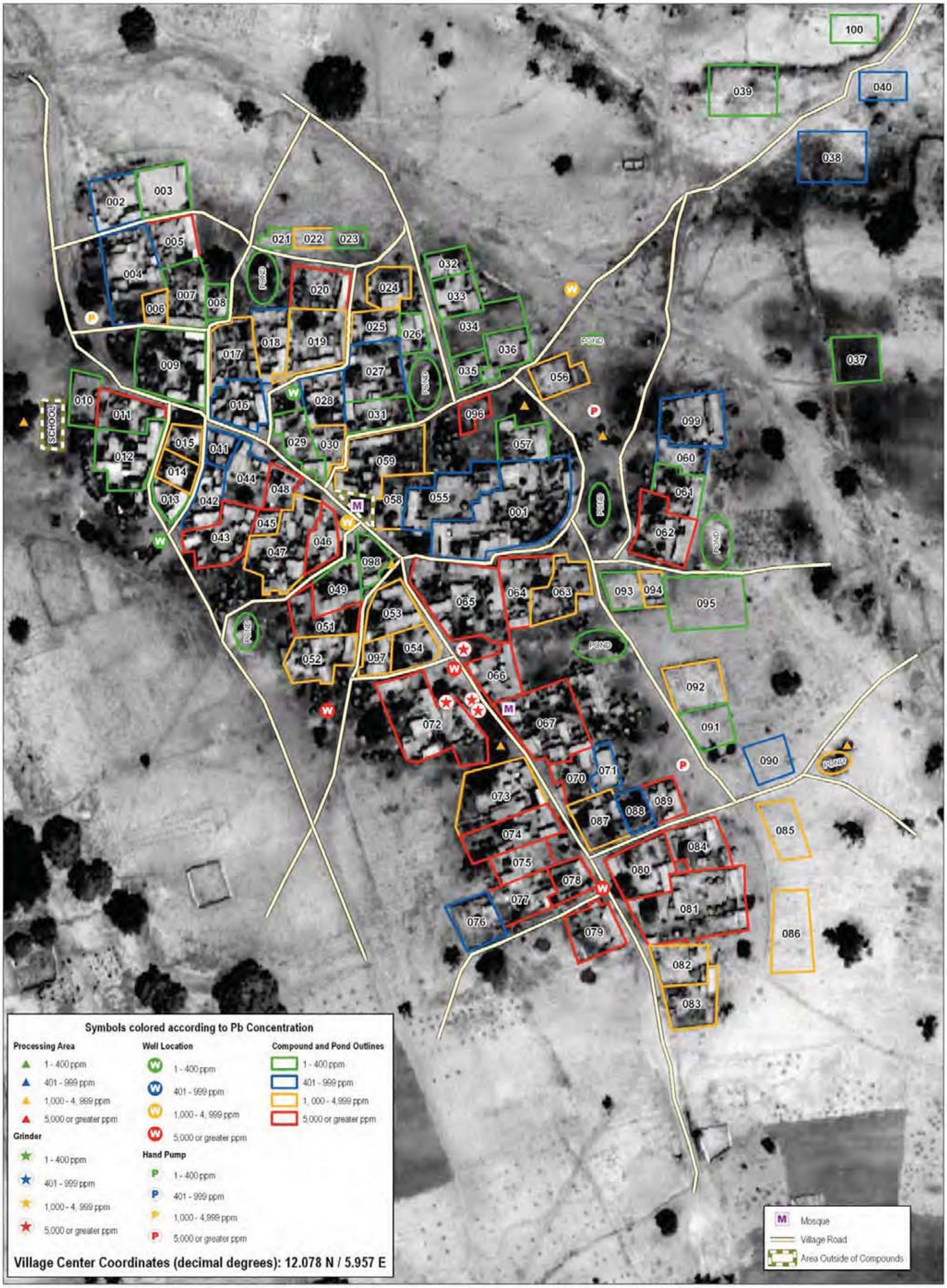
Figure 1 UNICEF Map of Nigeria



Map of Nigeria and Zamfara State

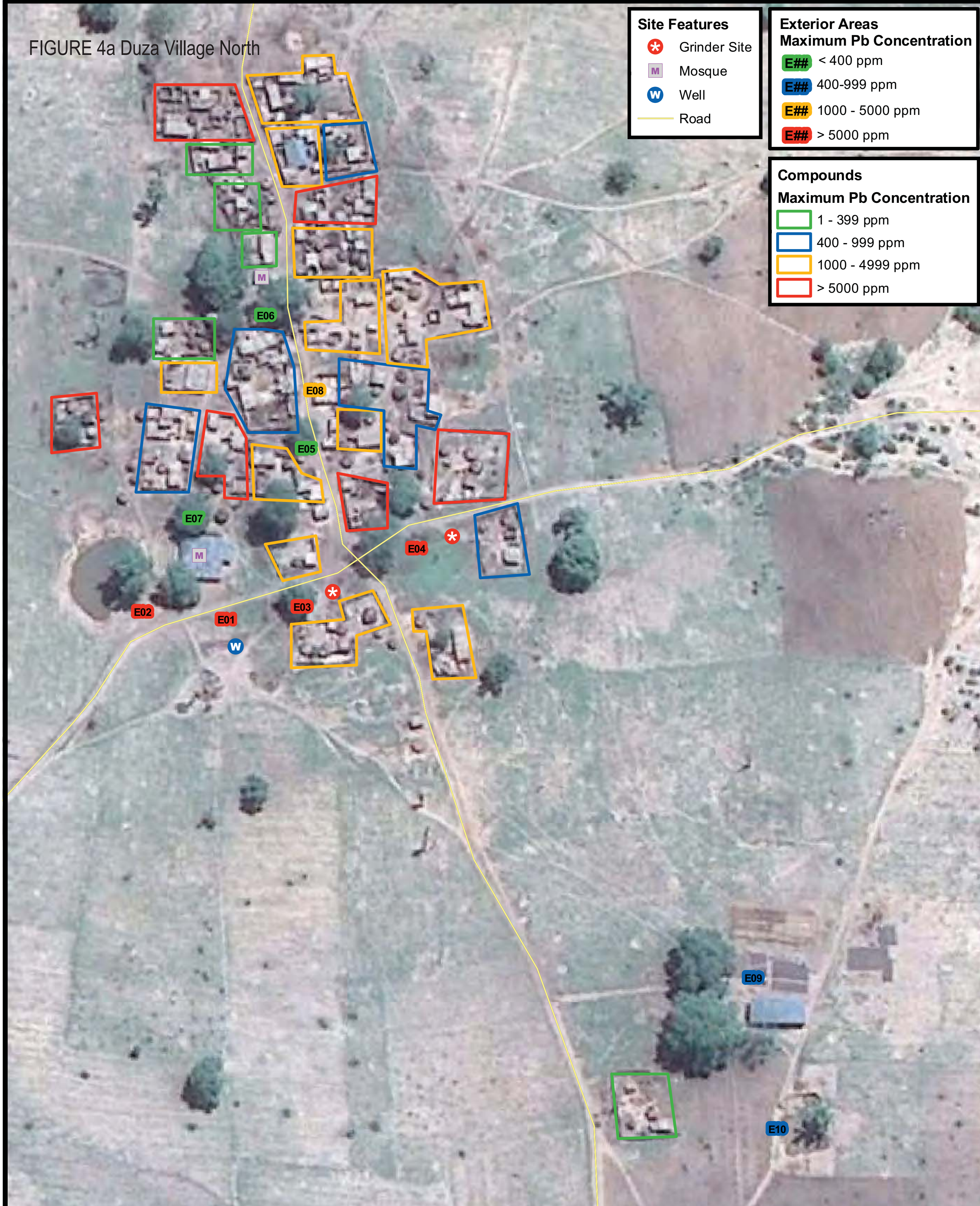
Figure 2 UNICEF Map of Zamfara

FIGURE 3 Abare Village



PROJECT NAME **Nigeria Initiative**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Abare Village Map** **Compound and Exterior Soil Lead Contamination Pre-remediation**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE International/Nigeria/Abare/abare_comppounds PRINT DATE November 8, 2010 PROJECT NUMBER 10075 - Nigeria Initiative	Map Coordinate System: WGS 1984 PROJECT MANAGER I. von Lindern CARTOGRAPHER B. Bailey	Map Scale: 1:1,600 0 100 200 Feet 0 20 40 Meters



Project Name

Nigeria Initiative

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Duza North Village Map

Compound and Exterior Soil Lead Contamination Pre-remediation

TerraGraphics
Environmental Engineering, Inc.
www.terragraphics.com

File: TungarDaji_Compounds.mxd

Project Number: 10075 Nigeria Initiative

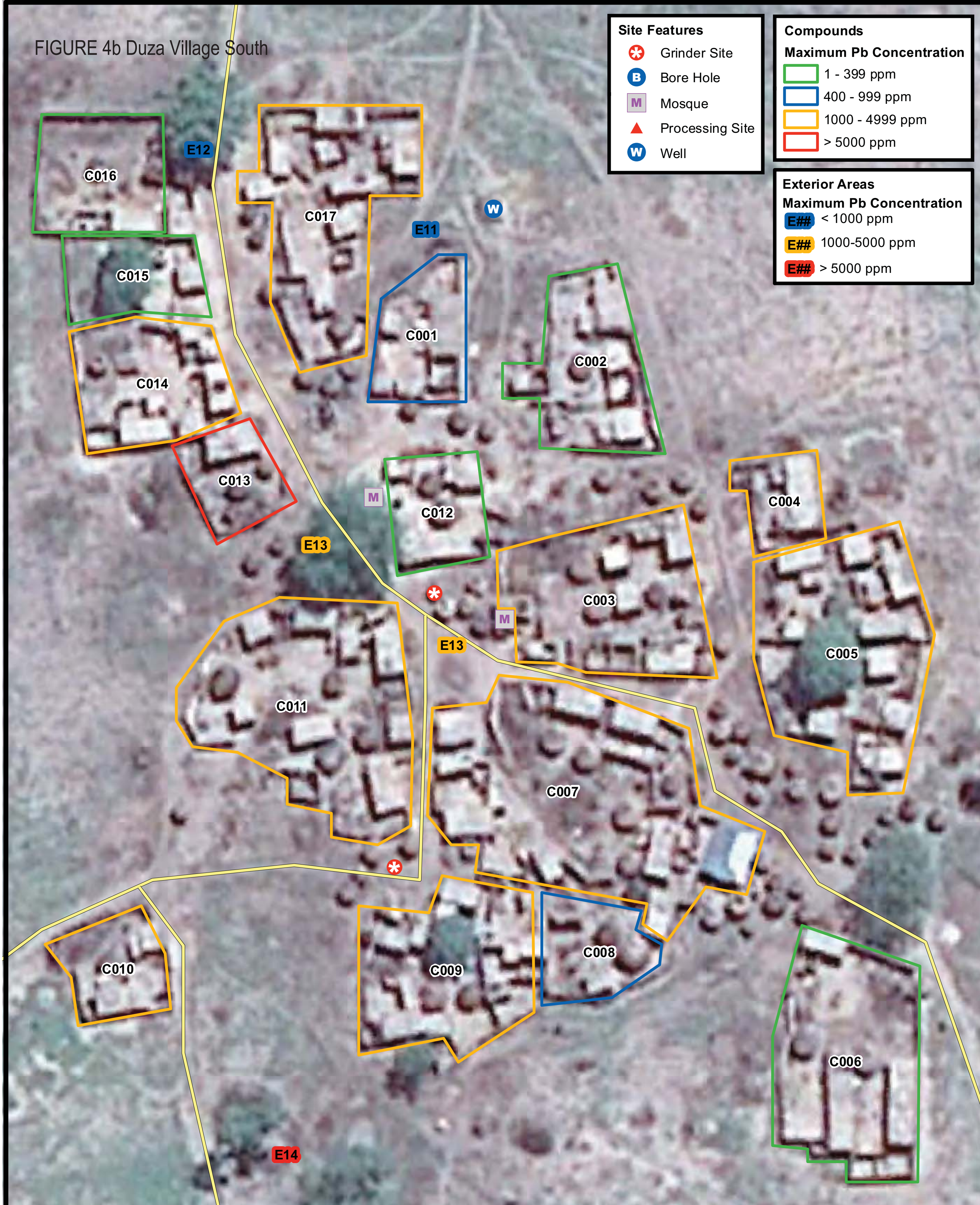
Map Coordinate System: WGS 1984

Project Manager: I. Vonlindern

Cartographer: A. Hanna

Map Scale: **1:1570**

0 87.5 37 175 Feet



Project Name

Nigeria Initiative

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Duza South Village Map

Compound and Exterior Soil Lead Contamination Pre-remediation

TerraGraphics Environmental Engineering, Inc.
www.terragraphics.com

File: TungarDaji_Compounds.mxd

Project Number: 10075 Nigeria Initiative

Map Coordinate System: WGS 1984

Project Manager: I. Vonlindern

Cartographer: A. Hanna

Map Scale: **1:717**

0 40 80 Feet

FIGURE 5 Sunke Village

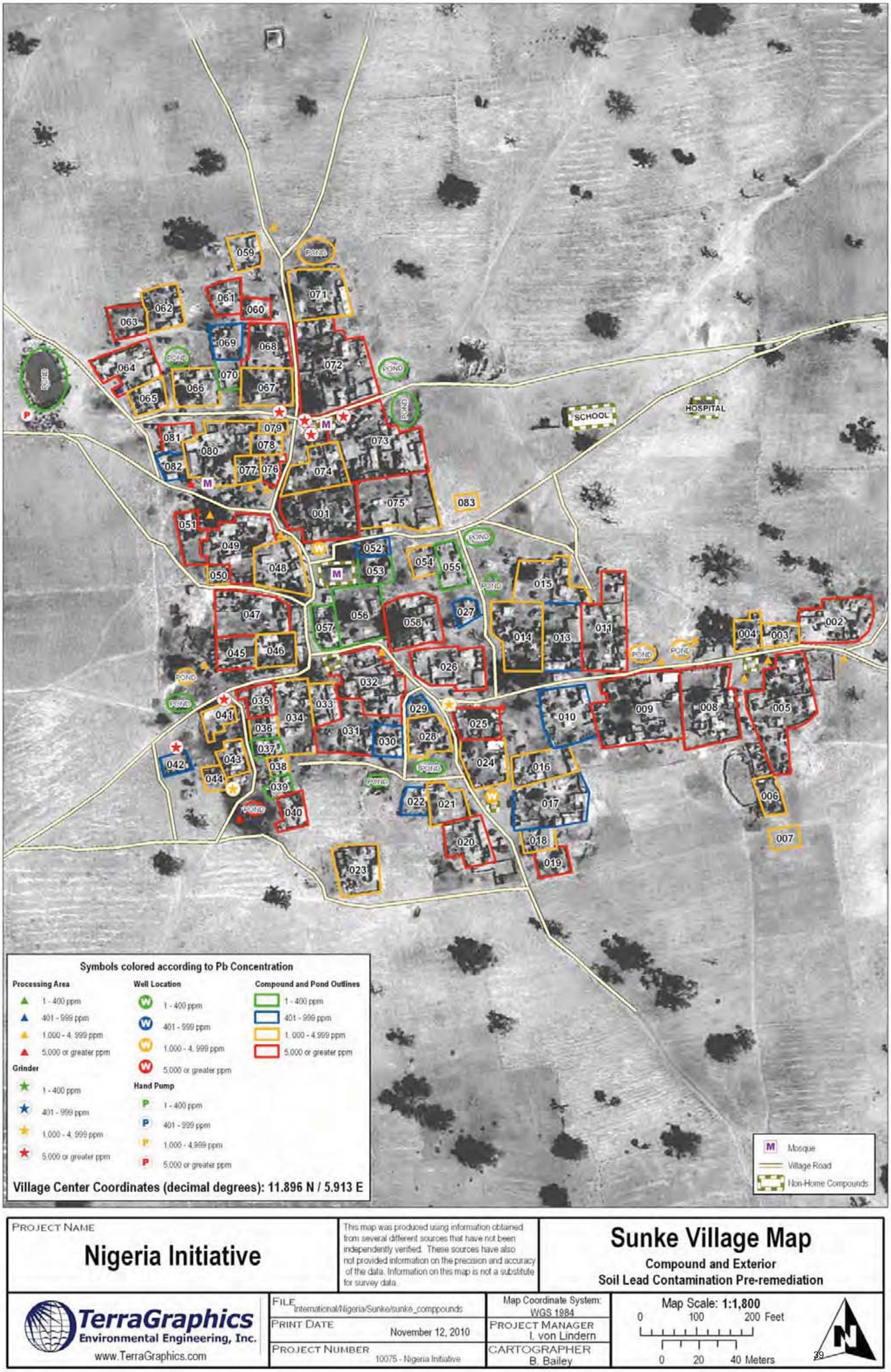
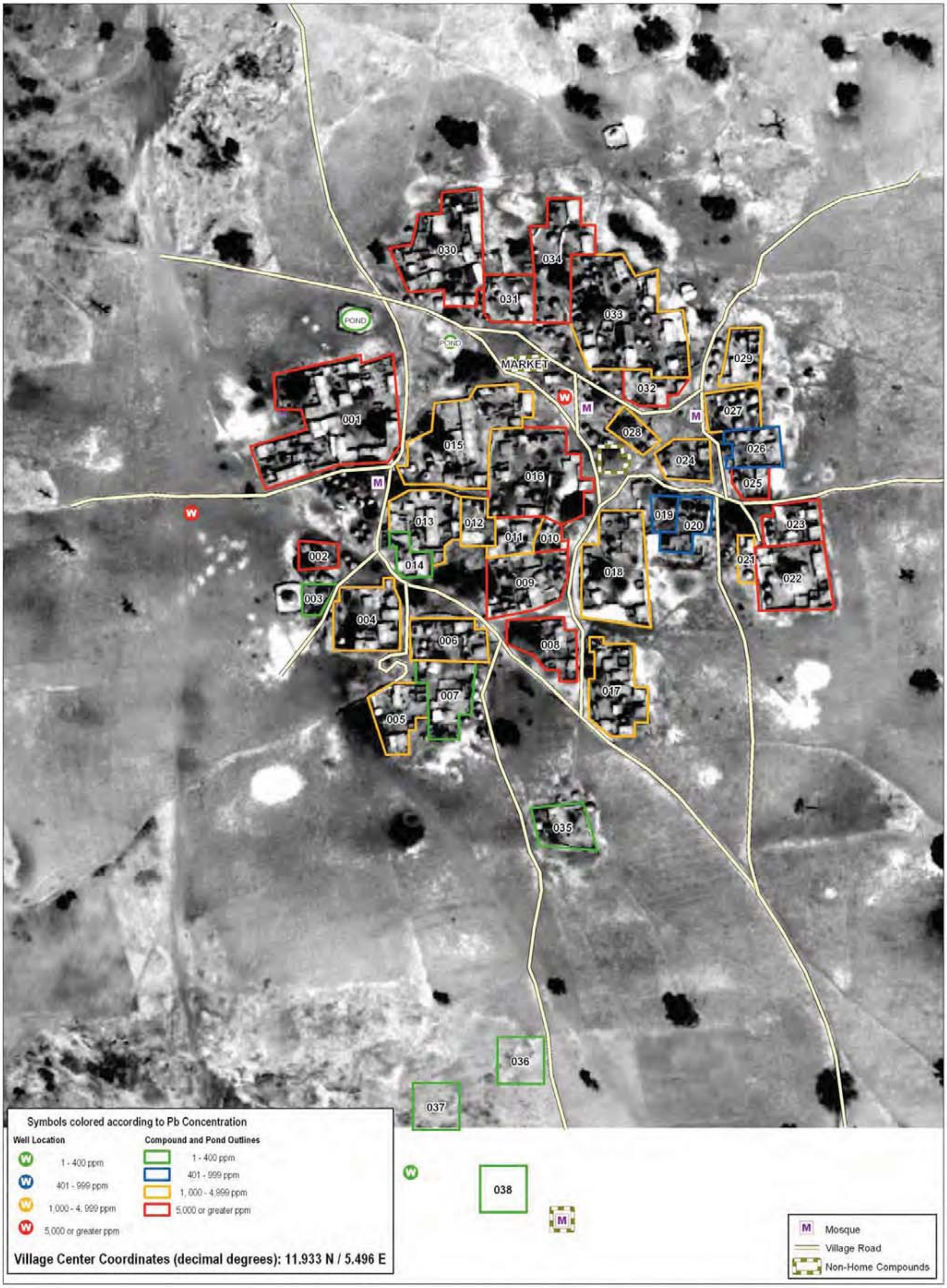


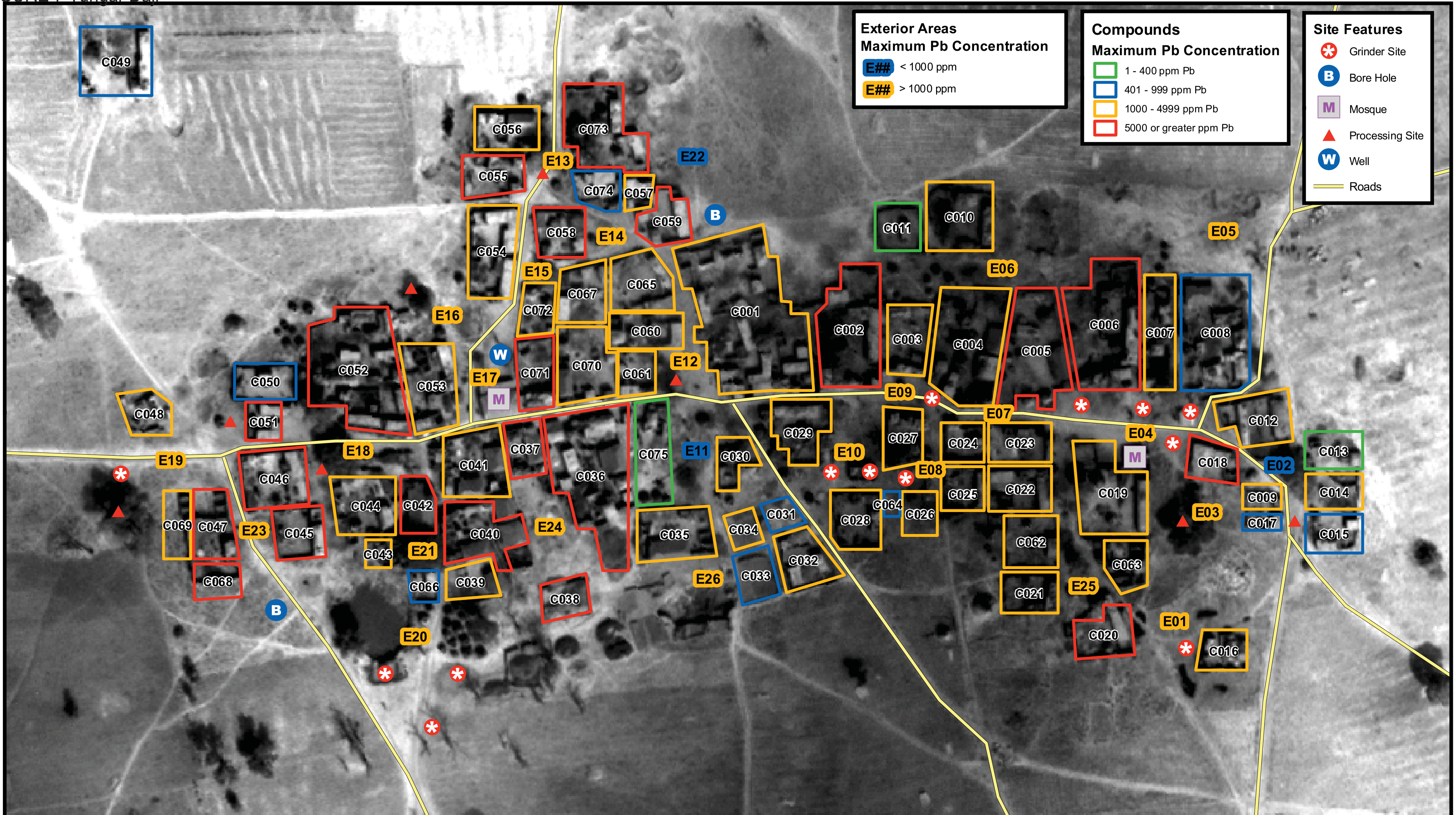
FIGURE 6 Tungar Guru



PROJECT NAME **Nigeria Initiative**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Tugar Guru Village Map** **Compound and Exterior Soil Lead Contamination Pre-remediation**

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE International/Nigeria/Abare/tugar_guru_comppounds PRINT DATE November 1, 2010 PROJECT NUMBER 10075 - Nigeria Initiative	Map Coordinate System: WGS 1984 PROJECT MANAGER I. von Lindern CARTOGRAPHER B. Bailey	Map Scale: **1:1,400** 0 100 200 Feet 0 20 40 Meters

FIGURE 7 Tungar Daji



Project Name

Nigeria Initiative

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Tungar Daji Village Map

Compound and Exterior Soil Lead Contamination Pre-remediation

TerraGraphics Environmental Engineering, Inc. www.terragraphics.com

File: TungarDaji_Compounds.mxd

Project Number: 10075 Nigeria Initiative

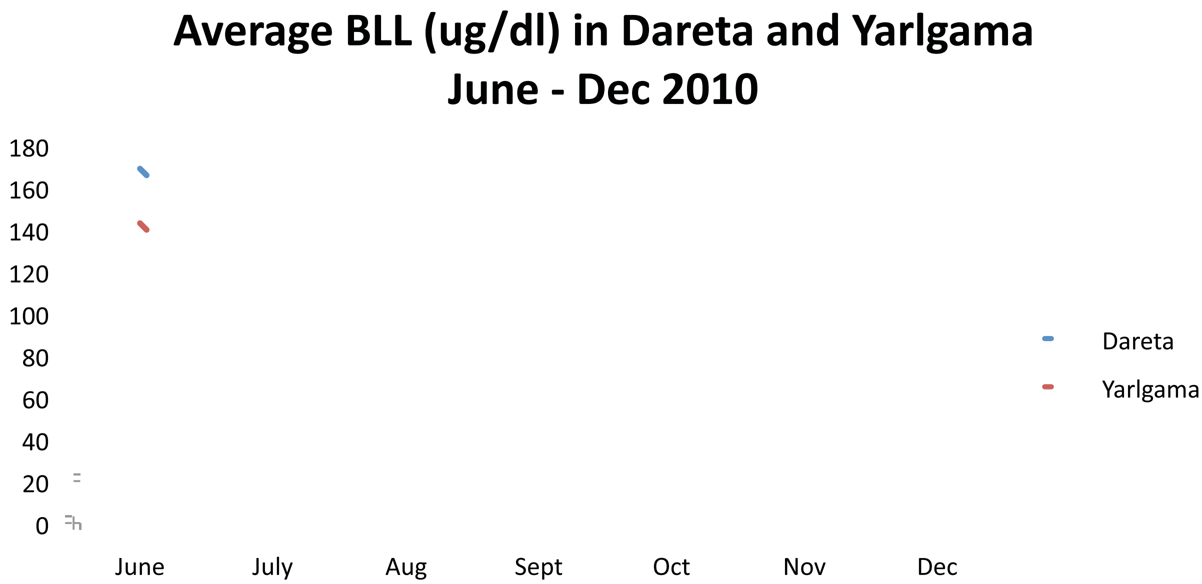
Map Coordinate System: WGS 1984

Project Manager: I. Vonlindern

Cartographer: A. Hanna

Map Scale:**1:1,500**

Figure 8. Average Blood Lead Levels (BLL) in Phase 1 Villages as of January 2011



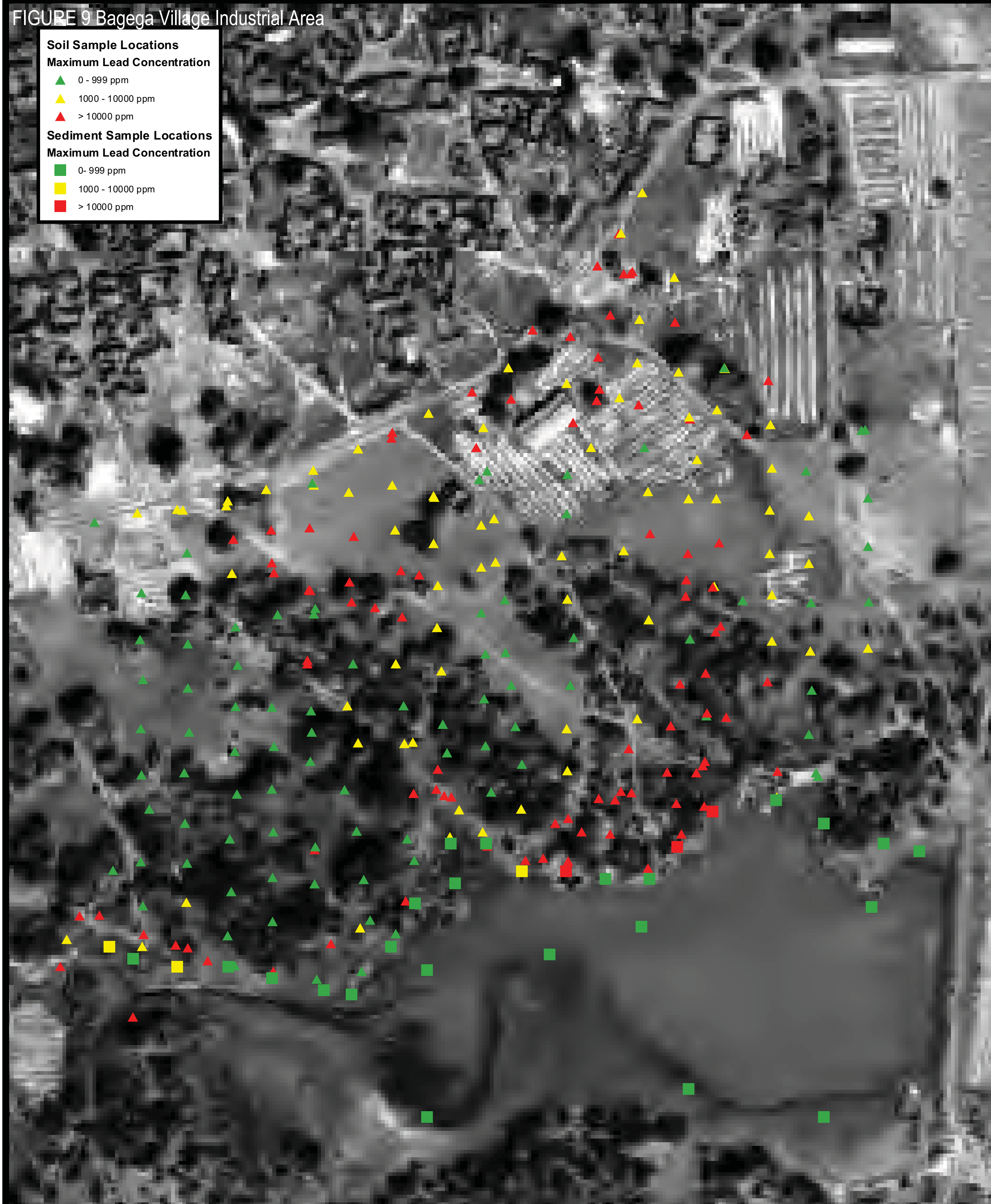


FIGURE 9 Bagega Village Industrial Area

Project Name

Nigeria Initiative

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

Bagega Industrial Area

Industrial Area
Soil Lead Contamination Pre-remediation

TerraGraphics Environmental Engineering, Inc.
www.terragraphics.com

File: TungarDaji_Compounds.mxd

Project Number: 10075

Map Coordinate System: WGS 1984

Project Manager: I. Vonlindern

Cartographer: A. Hanna

Map Scale: **Not to scale**

N

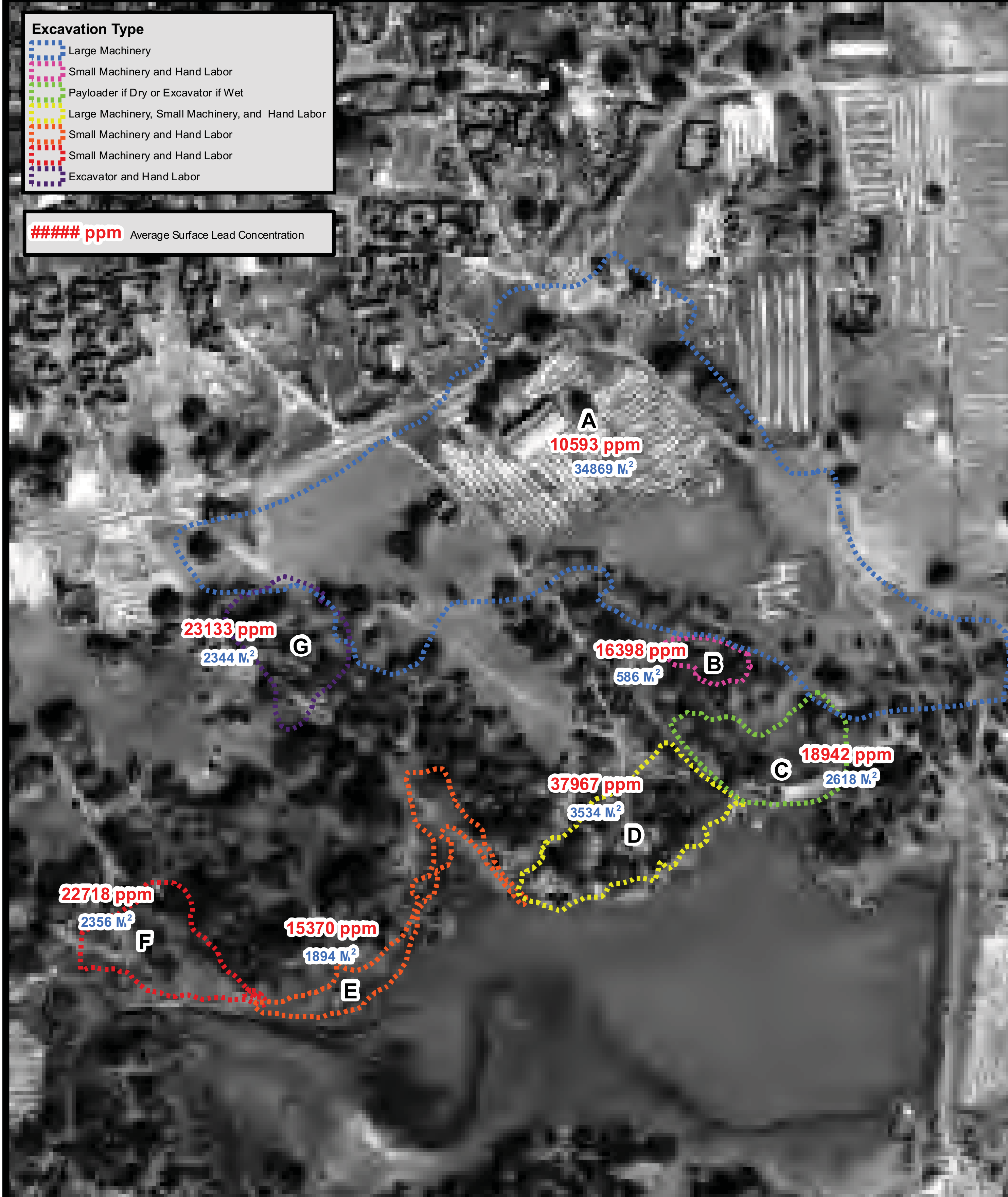


FIGURE 10 Bagega Village Industrial Area Approach

Project Name **Nigeria Initiative**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Bagega Industrial Area** **Industrial Area** **Delineated Excavation Areas**

TerraGraphics Environmental Engineering, Inc.
www.terragraphics.com

File: TungarDaji_Compounds.mxd

Project Number: 10075

Map Coordinate System: WGS 1984

Project Manager: I. Vonlindern

Cartographer: A. Hanna

Map Scale: **Not to scale**

N

Table A. Remediation Statistics for Villages – Compounds, Exteriors, and Rooms

Village	No. cmpds	No. cmpds remediated	No. exteriors remediated (not incl. ponds)	No. ponds remediated	No. rooms concreted
Tungar Guru	33	31	8	1	30
Sunke	80	73	28	10	64
Abare	93	75	21	0	103
Tungar Daji	79	72	17	10	118
Duza	40	31	33	2	15
Dareta (Phase I)	98	89	N/A	4	N/A
Yargalma (Phase I)	64	59	N/A	3	N/A
CERF Totals	320	282	107	23	330
Grand Total	482	430		30	

Table B. Village Demographics and Compound Remediation Statistics

Major funding source for remediation	**Village**	**Pop. est. (based on 2006 Anka LGA census data)**	**No. children $\leq$ 5 yrs. (based on 20% of pop.**
CERF/BI/TG	Tungar Guru	573	115
CERF/BI/TG	Sunke	2379	476
CERF/BI/TG	Abare	1486	297
CERF/BI/TG	Tungar Daji	1260	252
CERF/BI/TG	Duza	687	137
ZMoE/BI/TG	Dareta	1033	207
ZMoE/BI/TG	Yargalma	1133	227
UNKNOWN	Bagega (est.)	7323	1465
Totals		**15874**	**3175**

Table C. Children Treated in MSF Clinics (as of Jan 2011)
(Clinics in Duza and Tungar Daji to open in March 2011)

Number of ≤ 5 yrs per census in Abare, Dareta, Yarlgama, Sunke & Tungar Guru	**1466**
Number of ≤5 yrs screened	1284
Percentage of ≤5 yrs screened	88%
Number of ≤ 5 yrs in chelation program	926
Percentage of ≤5 yrs in program of total	63%
Percentage of ≤5 yrs screened ≥ 45 ug/dl	74%

Table D. Pre-Remediation Pb Levels (mg/kg) in Compounds in 5 CERF villages.
(A compound was placed into a category based on the maximum reading in the compound.)

	<400	**400-999**	**1000-4999**	**5000-24999**	**25000-100000**	**>100000**
Abare	18	17	29	4	8	17
T. Guru	2	4	14	12	0	1
Sunke	7	7	34	10	22	0
T Daji	2	8	35	20	6	3
Duza	9	6	17	2	6	0
TOTALS	38	42	129	48	42	21

Table E. Schedule of Activities tracks the work completed to date by village since September 2010

Blacksmith/TerraGraphics Zamfara Lead Remediation Plan					2/28/2011								
												BREAK	BREAK
Work	3-Oct	10-Oct	17-Oct	24-Oct	31-Oct	7-Nov	14-Nov	21-Nov	28-Nov	5-Dec	12-Dec	19-Dec	26-Dec
General Activity	Procure heavy equip.	Procure Supplies, Supply del - to Abare		Supply delivery to Tungar Guru	Supply to Sunke, start Comp Bagega		Bagega Comp done Demob Exc	Supply to Tungen Daji, Duza	Add. Supply to Sunke	Add. Supply to TD & Duza	Demob. payloader	Break 12/23 to 12/28	
Abare	Mapping, Sampling and Characterization	Landfill location & const.	Remediation	Remediation	Remediation	Finish Rem., cement	Finish Rem., Cement	Finish Cement, Village work					
Tungar Guru		Mapping, Sampling and Characterization	Landfill location & const.	Train, Remediation	Remediation	Rem., Cement	No Work	Cement, End Village Work					
Sunke			Landfill location	Landfill const., Mapping, Sampling and Characterization	Finish Mapping, Sampling and Characterization	Remediation	Remediation, Expand Landfill	Remediation	Remediation	Remediation, Cement	Remediation, Cement		
Tungar Daji					Landfill loc & const, start Mapping, Sampling and Characterization	Mapping, Sampling and Characterization	Mapping, Sampling and Characterization	Start Remediation	Remediation	Remediation	Remediation, Cement		
Duza					Landfill Const.			Mapping, Sampling and Characterization	Remediation	Remediation	Remediation		
Bagega													

2-Jan	9-Jan	16-Jan	23-Jan	30-Jan	6-Feb	13-Feb	20-Feb	27-Feb
Staff returns, plan	Remobilize heavy Equipment					Survey Crew to Bagega Industrial Area	Demobilize heavy Equipment and Reports	Reports
	Security Lockdown	Excavate ponds	Landfill Closed					
	Security Lockdown				Excavate Ponds	Landfill Closed		
Planning	Security Lockdown	Remediation; 1 interior; exterior hand labor	Cement; Remediation; 1 interior; all exteriors	Exteriors and 57 rooms to cement; excavate ponds;	Exteriors and cement;	Landfill Closed		
Planning	Security Lockdown	Remediation; 7 cpds; incl little Daji	remediation and exteriors; 114 cement	remediation and exteriors; excavate ponds	Landfill closed			
Planning	Security Lockdown	planning	planning	exteriors	Exteriors and cement;	Landfill Closed		
Planning; Prelim. Survey of Cpds, Exteriors and Industrial Area	Security Lockdown	Mapping, Sampling and Characteriz. of Cpds, & Ext.	Mapping, Sampling and Characteriz. of Cpds, & Ext.	Mapping, Sampling and Characteriz. of Cpds., Ext. & Industrial Area	Mapping, Sampling and Characteriz. of Cpds., Ext. & Industrial Area	Mapping, Sampling and Characteriz. of Cpds., Ext. & Industrial Area	Mapping, Sampling and Characteriz. of Cpds., Ext. & Industrial Area	

Table F. Waste and Landfill Volumes in 5 CERF Villages

Abare		**cu.m**
	Waste Volume	1050
	LF Volume	1500
Sunke		
	Waste Volume	2400
	LF #1 Volume	3300
	Waste Volume	625
	LF #2 Volume	1000
T. Guru		
	Waste Volume	800
	LF Volume	1000
Duza		
	Waste Volume	1162.5
	LF Volume	1737.5
T. Daji		
	Waste Volume	840
	LF Volume	1120

Table G. GPS Coordinates for 5 CERF Villages and Landfills

Abare	**Town**	**N 12° 4.559'**	**E 5° 57.450'**
	Town	N 12° 4.521'	E 5° 57.433'
Landfill	SW	N 12° 5.030'	E 5° 57.060'
	SE	N 12° 5.032'	E 5° 57.054'
	NE	N 12° 5.041'	E 5° 57.064'
	NW	N 12° 5.043'	E 5° 57.057'
		Open 10/14/2010	closed 1/25/2011
Sunke	Town	N 11° 54.210'	E 005° 54.088'
	Town	N 11° 53.720'	E 005° 54.698'
Big Landfill	SW	N 11° 53.650'	E 005° 55.206'
	SE	N 11° 53.650'	E 005° 55.218'
	NE	N 11° 53.674'	E 005° 55.213'
	NW	N 11° 53.672'	E 005° 55.204'
		Open 10/25/2010	11/18/2010 expanded
LF Extension	SW	N 11° 53.641'	E 005° 55.223'
	SE	N 11° 53.643'	E 005° 55.229'
	NE	N 11° 53.662'	E 005° 55.225'
	NW	N 11° 53.660'	E 005° 55.218'
		closed 2/23/2011	
T. Guru	Town	N 11° 56.000'	E 005° 29.740'
	Town	N 11°55.977'	E 005°29.780'
Landfill	SW	N 11° 55.780'	E 005° 30.055'
	SE	N 11° 55.782'	E 005° 30.059'
	NE	N 11° 55.793'	E 005° 30.057'
	NW	N 11° 55.789'	E 005° 30.050'
		open 10/20/2010	closed 2/26/2011
Duza	Town	N 11º 54' 03.88"	E 06º 04' 42.13"
	Town	N 11º 53' 42.13"	E 06º 04' 45.88"
Orig Landfill	SW	N 11° 54.059'	E 006° 04.863'
	SE	N 11° 54.056'	E 006° 04.868'
	NE	N 11° 54.068'	E 006° 04.883'
	NW	N 11° 54.071'	E 006° 05.879'
Landfill Extn.	SW	N 11° 54.051'	E 006° 04.856'
	SE	N 11° 54.048'	E 006° 04.857'
		open 11/2/2010	close 2/24/2011
T. Daji	Town	N 11º 54' 16.30"	E 06º 05' 34.45"
	Town	N 11º 54' 02.35"	E 06º 05' 38.35"
Landfill	SW	N 11° 54.323'	E 006° 05.869'
	SE	N 11° 54.311'	E 006° 05.877'
	NE	N 11° 54.325'	E 006° 05.875'
	NW	N 11° 54.312'	E 006° 05.872'

Table H. Pre-Remediation Pb Levels (mg/kg) in Bagega (124 of est. 370 compounds characterized as of 2/23/2011)
(A compound was placed into a category based on the maximum reading in the compound.)

Action Level (Pb mg/kg)	<400	401-999	1000-4999	>5000	Total
Zone A	0	0	6	18	24
Percentage Zone A	0%	0%	32%	68%	
Zone B	1	32	163	15	35
Percentage Zone B	4%	7%	46%	43%	
Zone C	2	42	16	15	37
Percentage Zone C	4%	8%	38%	50%	
Zone D	7	4	7	10	28
Percentage Zone D	32%	14%	18%	36%	
Total	10	11	45	58	124
Percentage of Total	8%	9%	36%	47%	

Table I. Bagega Industrial Area – Projected Remedial Actions and Typical Lead Levels

Remedial Sub-area	Projected Remedial Action	Area in Square Meters	Typical Lead Level (mg/kg)
Area A	Flat – Accessible to Grader	34,869	35271
Area B	Hand Labor / Small Equip.	586	30218
Area C	Pits Accessed by Excavator	2,518	31566
Area D	Ore Mounds by Hand Labor	3,534	50775
Area E	Shoreline w Excavator	1,894	25517
Area F	Shoreline w Small Equip	2,356	23932
Area G	Sluicing Pits Hand labor	2,344	30236
Lead Concentrations in Specific Sub-areas			
Grinding Area			9540
Flat Area			12730
Sluicing Ponds			16461
Beach Area			16130
Ore Piles			42605
Mosque Area			2543
Adjacent Farm Area			1333
Wooded Area			629

Table J. Housing Characteristics in Anka and Bukkuyum LGAs (Nigeria census, 2006)

	# Households	Structure	Floor	Wall	Roof
		Tradit. Hut	Earth/ Mud/ Mud Bricks	Mud/ Reed	Earth/ Mud/ Mud Bricks
Nigeria	28,197,085	3,944,091	10,325,169	10,844,894	2,689,455
		14%	37%	38%	10%
Zamfara	592,106	166,227	371,642	421,880	211,939
		28%	63%	71%	36%
Anka	26,340	10,871	15,628	17,163	9,656
		41%	59%	65%	37%
Bukkuyum	38,356	15,145	25,775	29,249	14,533
		39%	67%	76%	38%

Table K. Household Characteristics in Anka and Bukkuyum LGAs (Nigeria census, 2006)

	# Households	Domestic Water Supply	Primary Lighting Fuel	Access to Television
		Well	Electricity	No access to television
NIGERIA	28,197,085	10,087,476	10,422,427	14,058,014
		36%	37%	50%
ZAMFARA	592106	226541	110070	322545
		38%	19%	54%
Anka	26340	15523	1502	19585
		59%	6%	74%
Bukkuyum	38356	18226	2495	23772
		48%	7%	62%

Table L. Literacy and School Attendance in Anka and Bukkuyum (Nigeria census, 2006)

Nigeria						
Age Group	**Total**	**Literate**	**Not Literate**	**% Not Literate**	**Never attended School**	**% Never Attended**
6 - 9	15,427,128	6,927,539	8,499,589	55%	5,440,022	35%
10 – 14	16,135,950	11,475,145	4,660,805	29%	3,631,303	23%
15 – 19	14,899,419	11,886,674	3,012,745	20%	3,347,333	22%
20 – 24	13,435,079	10,410,997	3,024,082	23%	3,426,959	26%
Total	113,258,571	75,751,576	37,506,995	**33%**	36,141,352	**32%**
Males Total	57,407,131	40,915,736	16,491,395	29%	15,987,013	28%
Females Total	55,851,440	34,835,840	21,015,600	38%	20,154,339	36%
Zamfara						
6 - 9	411,848	146,460	265,388	64%	272,986	66%
10 – 14	357,780	190,933	166,847	47%	187,210	52%
15 – 19	314,934	175,659	139,275	44%	172,091	55%
20 – 24	275,375	144,007	131,368	48%	163,198	59%
Total	2,475,679	1,210,444	1,265,235	**51%**	1,502,624	**61%**
Males Total	1,229,091	696,641	532,450	43%	653,541	**53%**
Females Total	1,246,588	513,803	732,785	59%	849,083	**68%**

APPENDICES

EMERGENCY CLEANUP STRATEGY FOR FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC

Phase 2 Village Remediation Activities
September to December, 2010

PROJECT OPERATIONS DOCUMENTS

September 5, 2010

Prepared by TerraGraphics Environmental Engineering
Moscow, Idaho, USA

ZAMFARA SUMMARY OF RECOMMENDATIONS

EMERGENCY CLEANUP STRATEGY FOR FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC – September to December, 2010

Prepared by TerraGraphics Environmental Engineering Moscow, Idaho, USA

Background: In response to a report from Medecins Sans Frontieres (MSF) of an outbreak of apparent heavy metal poisoning in Zamfara State, Nigeria, the Nigerian Ministry of Health (MOH) requested technical assistance from the Lead Poisoning Prevention Branch of the U.S. Centers for Disease and Prevention (CDC). In addition to the CDC technical assistance and equipment was provided by the Blacksmith Institute New York and TerraGraphics Environmental Engineering (TG), Moscow, Idaho, USA. This team collaborated with MSF, the Zamfara Ministries of Health (MOH), Environment and Solid Minerals (MOE), and the World Health Organization (WHO) in investigating and characterizing the epidemic in two villages, Yargalma in Bukkuyum LGA, and Dareta in Anka LGA. MSF and MOH collaborated in developing hospital facilities in Bukkuyum and Anka to treat children from these villages. Blacksmith and TerraGraphics similarly collaborated with MOE to remediate these villages in June and July of 2010, providing clean homes for the children returning from hospitalization. Nine other villages were implicated in the epidemic, but were not assessed. Some are currently inaccessible to NGO or CDC personnel.

The source of the outbreak is associated with artisanal scale gold ore processing that occurs at the villages. For several months grinding operations were conducted at numerous sites in these villages and crushing, washing and gold recovery were undertaken within the residential compounds. A particularly dangerous ore, high in lead content (oftentimes exceeding 10% Pb) was introduced into the processing stream in early 2010. Women villagers processed this ore within the compounds, with infants at their side, assisted by older children. Local customs preclude women leaving the compounds without permission of their husbands, and many have had no relief from these exposures for several months. When death and illnesses among young children became prevalent, the Emir of Anka ordered these operations moved outside the residential areas approximately ½ kilometer from the villages. These operations were removed in early May, 2010. Extremely high levels of lead in soils and dust remained in the compounds and former grinding and crushing sites.

Exposure Summary: The CDC Response Team confirmed diagnosis of lead poisoning in numerous children and subsequent environmental sampling showed extremely high concentrations lead and mercury in several media. Several exposure pathways are active and offer excessive lead intake to residents. More than 4000 children under age five years are considered at risk of death or serious short and long-term irreversible health effects.

Chelation therapy on an in-patient basis is provided at newly constructed MSF clinics in Anka and Bukkuyum. The clinics have the capacity to treat less than 50% of the children requiring immediate hospitalization. The course of treatment is 3-4 weeks. The majority of village children are weeks to months away from treatment. These children remain at risk of death or severe CNS damage. Treatment cannot be effectively implemented if hospitalized children are returned to contaminated communities. Relocation, for other than hospitalization, is not effective due to cultural considerations and lack of facilities.

As a result, MSF is limiting treatment to children from Yargalma and Dareta villages and those at immediate risk of death or severe brain damage in the other villages. Approximately 430 individual children have been treated to date, with several undergoing additional rounds of chelation. About 2/3rds of these children are from Yargalma 1/3rd from Dareta village.

Prognosis: This situation is a public health crisis with several hundred deaths of children under age five years of age having occurred due to lead poisoning. Mortality rates are unprecedented in public health records with estimates of >40% of children presented in one village dying. Several hundred children have been tested and show severe lead poisoning in more than five villages, with individual readings > 350 µg/dl. Dozens of children are currently hospitalized and mortality is continuing, with hundreds awaiting treatment. Numerous children have been adversely affected, but the full extent of the problem has not yet been determined. Extremely hazardous exposures remain in these children's homes, leaving hundreds of children at risk of extreme health effects, mortality, and potentially compromising outpatient treatment efforts. Adult exposures remain unresolved, but are also likely to be extreme.

Medical, Public Health and Environmental Response**:** A comprehensive, integrated response is underway through the coordinated efforts of State and federal Nigerian Health and Environmental Agencies, and local governments (LGAs), Village Chiefs, MSF, CDC, WHO UNICEF and Blacksmith/TerraGraphics.

In June of 2010, the Zamfara State government requested that Blacksmith/TerraGraphics collaborate with the MOE to develop an emergency removal proposal for the villages of Yargalma in Bukkurum LGA, and Dareta in Anka LGA. The plan addressed immediate measures to reduce exposures in the community to provide relief for currently poisoned children and adults and to provide a low lead environment for newborns and children returning from hospitalization and treatment. In addition the Ministry has requested advice regarding development of a safe-mining program to address longer-term issues and prevent re-occurrence of such episodes. This plan was offered in coordination with ongoing and anticipated medical, public health, epidemiologic, environmental and public information efforts. The plan was implemented in June and July 2010 in the Dareta and Yargalma villages and was largely completed prior to the rainy season. Two landfills remain to be closed in these villages.

Unfortunately, the program was suspended in mid-July as construction was not possible during the rainy season. Nine other villages were implicated in the epidemic, but were neither assessed nor remediated. As a result, MSF has limited treatment to children from

Dareta and Yargalma villages and to those at immediate risk of death or severe brain damage in other villages.

Phase II of remediation activities are to address remediation needs in five villages identified in MSF and MOH outreach activities as having significant numbers of children in need of treatment. Those villages are Tungar Guru in Bukkuyam LGA; and Abare, Sunke, Tungar Daji and Duza in Anka LGA. Bagega in Anka LGA has also been identified, but is larger than the other villages combined and has not been allocated funding.

Sources to be Addressed: Currently, the primary exposure routes for both children and adults in these villages are: i) incidental ingestion of contaminated soils and dusts, ii) consumption of food contaminated by soil and dust sources, iii) ingestion of contaminated water, and iv) inhalation of contaminated dusts. The greatest ongoing and potential future exposures are associated with residual soil and dust lead contamination from past mining practices. Removal of these high lead content wastes will reduce direct contact, incidental ingestion, inhalation of suspended dusts, and contamination of food and water intake routes. Source areas in the five villages have not been specifically identified; however the main exposure locations are expected to be similar to those identified in mapping and characterizing Dareta and Yargalma as follows:

Former Crushing and Grinding Sites: There were nine former mining process locations in Yargalma and thirteen locations in Dareta. At the former processing sites, remnants of grinding machine stands, ore, sand, and other materials such as grinding wheels were observed. In both villages, the Chiefs were cooperative and supportive in identifying these locations. Soil lead concentrations in these areas exceeded 40, 000 mg/kg and ranged in size from 30-100 sq m. One site in Dareta surrounding the community well supported thirteen grinding machines and contained 770 cubic meters of waste of 3-4% lead (30,000 to 40,000 mg/kg).

Continuing Mining Operations**:** The mining activities resulted in extreme exposures at these locations to both children and adults. Children as young as eight years are employed in the washing step and children are observed mingling throughout these operations. Significant visible dust was observed coming from the grinding machines and the workers were observed to be covered with dust from the process. People performing the washing step of the process were observed using their hands to manually mix the mercury and the sand together, creating exposure risk and potential for take home contamination. Some gold ores showed concentrations exceeding the 10% lead upper detection limit of the sampling equipment (>100,000 mg/kg). These activities are currently banned by local authorities. Unfortunately, high concentrations observed in recent mapping efforts indicate that limited mineral processing is occurring, even in compounds that were remediated in June and July. Subsequently, local officials visited these homes and the owners were required to re-remediate the areas and dispose of the waste soils at the local landfill.

Soil and Dusts within the Compounds**: The most severe exposures to women, infants and toddlers continue to occur within the home compounds.** Children and adults routinely contact lead contaminated soils and dust (>10,000 ppm (mg/kg)) in the local compounds. Young children are especially vulnerable as they consume soil and dust that adheres to their hands during play and exploration activities. For younger children, the principal sources are household dusts that they contact on floors and surfaces during crawling and play activities. Due to local cultural practices, infants and mothers spend the majority of time within the compounds and are constantly exposed to these dusts. As children age, they spend more time in other compounds, streets, and play areas. As this neighborhood orientation evolves, contaminated soils and dusts in these areas become a more significant source in their exposure profile, both as a direct contact source and as materials tracked into the home. In Dareta, older children were observed to play directly in waste piles exceeding 40,000 ppm lead, 100 ppm mercury. Similar piles exist in Bagega village. These soils are also a major source of contamination to indoor dust, the dusts are ingested or inhaled directly, or can contaminate foodstuff. It is suspected that gold recovery operations and storage of processed materials continues to occur in some compounds.

Recommendations: TerraGraphics and Blacksmith recommend the following actions be undertaken immediately to reduce exposures to this population. Detailed analyses are available in supplemental memoranda.

i) Removal of contaminated soils from within the residential compounds and replacement with clean soils and concrete surfaces in both villages.
ii) Relocation of the high level wastes well to constructed repository and complete remediation of the surrounding area.
iii) Removal and replacement of contaminated soils from the former crushing and grinding sites in both villages.
iv) Cleaning of all personnel effects in each compound in association with the soil removal. Collection and replacement of all bags/sacks from within the compounds used in mining activities.
v) Development of on-site repositories at each village for disposal of all contaminated material. Locate this facility near the ongoing mining operations, encourage miners to dispose of their wastes in the repository, and provide hygiene facilities for workers to wash and change clothes before returning home.
vi) Work with international NGOs and Agencies to develop Best Management Practices (BMPs), and an associated enforcement mechanism, for these operations.
vii) Investigate the source and distribution of high lead ores and take steps to ensure safe and proper processing of these dangerous materials.
viii) Use every available tool to discourage mineral processing within the home compounds.

Four attached documents complete our proposal. These documents recommend project management, engineering, remediation, disposal, health and safety, and budget protocols.

i) ZAMFARA SITE CONTROL PLAN – **Phase 2 Village Cleanups**
ii) ZAMFARA EXCAVATION PLAN – **Phase 2 Village Cleanups**
iii) ZAMFARA LOGISTICS AND DISPOSAL PLAN – **Phase 2 Village Cleanups**
iv) ZAMFARA HEALTH AND SAFETY PLAN – **Phase 2 Village Cleanups**

ZAMFARA SITE CONTROL PLAN

Phase 2 Village Cleanups – September to December, 2010

STRATEGY FOR CLEANUP OF FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC

Prepared by TerraGraphics Environmental Engineering Moscow, Idaho, USA

This Memorandum includes a written description of Project Organization, Site Security, Traffic and Access Control, Water Control, Dust Control, Erosion and Sediment Control, and Health and Safety Measures that will be employed during the completion of Work.

Project Description

This remediation project (Project) is being conducted by Zamfara State **Ministry of Environment and Solid Minerals**, **(Ministry)** assisted by The **Blacksmith Institute (Blacksmith)** of New York, New York, USA and **TerraGraphics Environmental Engineering** (**TerraGraphics**) of Moscow, Idaho US through funding provided by the **United Nations Children's Emergency Fund (UNICEF).** The purpose of the Project is to eliminate excessive exposure to lead contaminated toxic soils located within five villages in the LGAs of Bukkurum and Anka, Zamfara State, Nigeria. The Project is being conducted in association with UNICEF, MSF, CDC, WHO and the LGAs. The Project is jointly funded by UNICEF and Zamfara State; and in-kind services and contributions from Blacksmith, TerraGraphics and MSF.

The corrective actions include excavation and removal of approximately 7000 cubic meters of toxic waste and lead contaminated soils located in the five villages. This quantity is based on remediation of an anticipated 250 compounds and associated ore processing areas within the five villages. Approximately 4000 cubic meters of contaminated soils are anticipated from within the residential compounds of the villages. About 2000 cubic meters of contaminated soils are found near former ore crushing and grinding sites, village streets and common areas; and an unknown amount is anticipated to require disposal from ore processing areas outside the villages, yet to be assessed. These soils and waste will be transported from the villages and placed in engineered landfills to be constructed near the ongoing mineral processing areas near each village.

The waste repository will also be available to dispose of wastes generated by the mineral processing activities.

Contaminated soils within the compounds will be removed by hand excavation utilizing local labor and construction practices. Process area wastes will be excavated by hand and with mechanical equipment. The excavated surfaces will be covered with clean soils and returned to original conditions, or covered with a protective layer of concrete. The landfills and clean soil repositories will be constructed with heavy construction equipment.

The Project will use specified health, safety, environmental, hazardous waste management and construction practices and procedures recommended by **Blacksmith** and **TerraGraphics**. These techniques are similar to those employed at these types of sites in the US. Workers will be informed of the risks associated with the contaminated materials and provided with protective clothing and dust masks. These techniques are in addition to, and intended to supplement, rather than replace, customary construction practices required and implemented in Zamfara State.

Strategy for Managing Remedial Actions: The attached memo entitled **SUMMARY OF RECOMMENDATIONS -EMERGENCY CLEANUP STRATEGY FOR FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC** provides a description of the major health and environmental considerations and the strategy for addressing those concerns. These concerns are addressed in three plans developed in draft form by TerraGraphics and provided to the Ministry as recommendations. Those plans are: a) **SITE CONTROL PLAN** (incorporating Health and Safety), b) **EXCAVATION PLAN**, c) **LOGISTICS AND DISPOSAL PLAN**, and d) **HEALTH AND SAFETY PLAN**

This document is the - **SITE CONTROL PLAN**

The following sections identify key Project team members, respective roles and responsibilities, provides a Site Map, Site Boundaries, Security and Access, and Best Management Practices to control contaminant migration and Health and Safety precautions to protect workers and public during construction activities.

Excavation, handling, and transport of the contaminated materials, capping of contaminated soil, placement of clean soils, and final grading and closure of the Site are addressed in the **EXCAVATION PLAN**.

Development of the borrow sources, construction of the on-site landfill, and disposal of the wastes are addressed in the **LOGISTICS AND DISPOSAL PLAN**.

Authority / Responsibilities

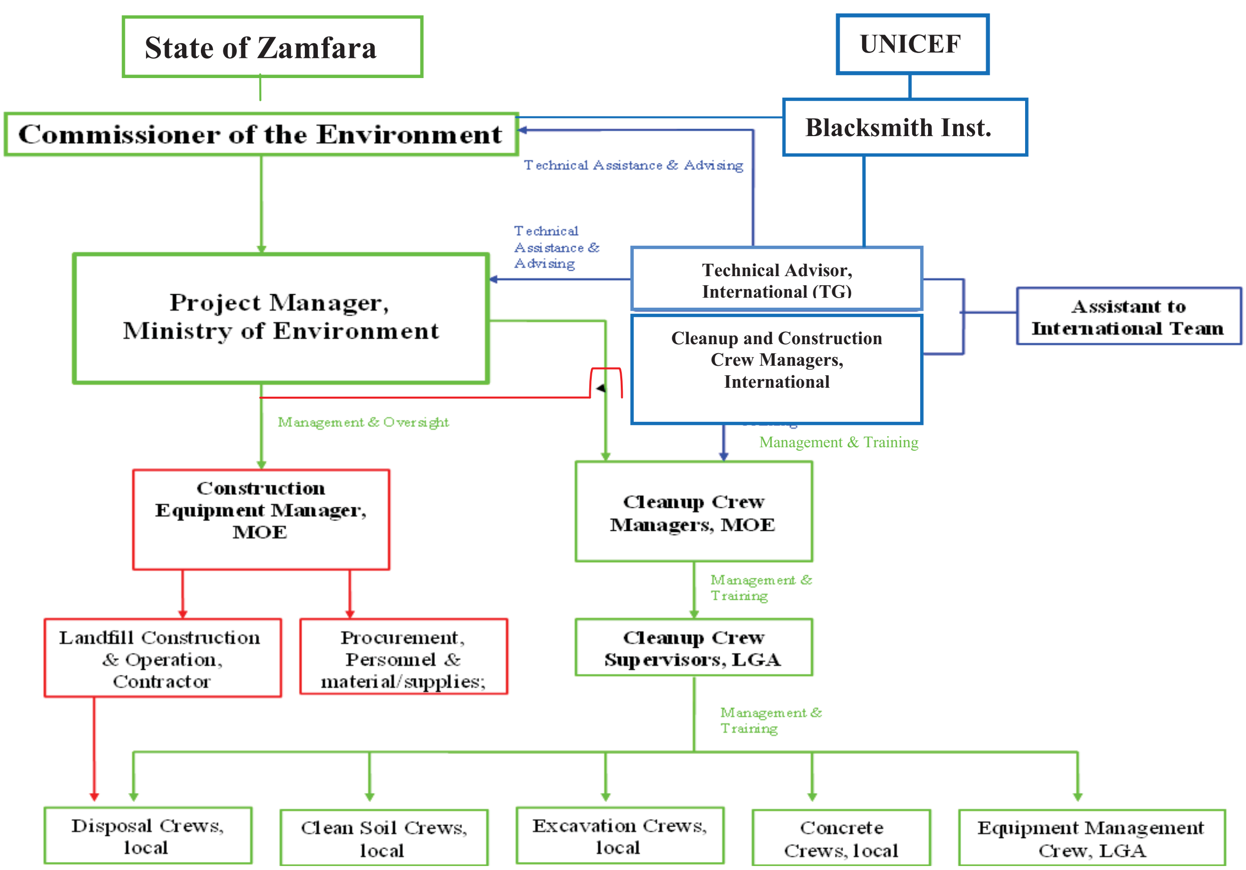
Figure 1 shows the Project Structure. The Project is in collaboration between the Zamfara **Ministry of Environment and Minerals (Ministry)** and the **UNICEF. Blacksmith** is administering the **UNICEF** effort through a cooperative agreement. **TerraGraphics** has been engaged to provide on-site technical oversight for **Blacksmith** and advice and technical assistance to the **Ministry**. Project funding and in-kind services are provided by the Zamfara State government, LGAs, UNICEF, Blacksmith, TerraGraphics, and MSF. The on-site remedial activities are being carried out jointly by the **Ministry** and **Blacksmith.** The **Ministry** is responsible for all services by the State of Zamfara. **Blacksmith** is responsible for all services provided through **UNICEF** funding. Each collaborator is responsible for their respective in-kind services. These responsibilities include Project and contractual oversight and administration of all contract engineering, administrative, financial, inspection, and construction management and support activities.

Logistic Support and Security: The Project is expected to require four months to complete. Initial personnel will be dispatched to the Site the first week of September, 2010. Construction is anticipated to commence the second week of October and be completed by the end of December 2010. Blacksmith and TerraGraphics International village remediation oversight teams will mobilize from Anka and Bukkuyum. International transportation and lodging in Anka and Bukkuyum will be provided by **Blacksmith** in association with MSF staff lodging facilities. In-country transportation and lodging in Gusau for Blacksmith and TerraGraphics personnel will be provided by the **Ministry**. Security in Anka and Bukkuyum will be provided by **Blacksmith** in association with MSF. Security to and from and within the villages will be provided by the **Ministry**. Transportation, lodging and security for Ministry of Environment and LGA personnel will be provided by the **Ministry** in association with the LGAs. **Blacksmith** will be responsible for Health and Safety requirements for Blacksmith and TerraGraphics personnel. The **Ministry** is responsible for Health and Safety requirements for Ministry and LGA personnel. **Contractors** shall be responsible for health and safety requirements for contracted labor and equipment operations. Activities implemented with UNICEF funds may be subject to supplemental accounting, health and safety, and reporting requirements. Each entity will be responsible to implement these additional requirements for their respective organizations.

Development and Operation of Clean Soil and Landfill Repositories: The **Ministry** is responsible to select and permit appropriate clean soil source and landfill sites; review and approve landfill and clean soil source development and operations plans, and assume responsibility for all long-term operations. The **Ministry** is responsible for all repository activities, including construction, disposal of waste, and closure of the repository. The **Ministry** will provide oversight of engineering, administrative, financial, inspection, and construction management activities. **TerraGraphics** will provide a generic landfill design, operations and closure plan, assist the Ministry in landfill and clean soil repository site selection and development of site-specific of operations plans. **Blacksmith** will engage appropriate construction services to develop the landfills and clean soil repositories, stage clean soils in the villages, dispose of contaminated soils, and assist in decontamination efforts. **Blacksmith** will provide a Construction Manager, who will work under **TerraGraphics** direction, to schedule, coordinate and provide oversight of contract equipment operations.

Excavation, Disposal and Replacement of Contaminated Soils. The **Ministry** is responsible to excavate and place all materials on the Site and to deliver the contaminated material to the constructed landfill**.** Local villagers will be retained to perform excavation, clean soil replacement, disposal, and support activities. The village crews will be supervised by LGA personnel, managed by Ministry of Environment managers in each village. All Ministry and LGA personnel will work under the direction of the Ministry of Environment Project Manager. All international in-country field personnel will work under the direction of the TerraGraphics Project Manager.

Figure 1. Project Organization and Structure



Blacksmith and **TerraGraphics** are providing advice and recommendations to the **Ministry** regarding methods and procedures to assure that sound environmental and health practices are employed. These methods are adapted from US experience and **Blacksmith** and **TerraGraphics** are working with the **Ministry** in an advisory and oversight role. **Blacksmith** and **TerraGraphics** have conducted on-site sampling and have worked with the **Zamfara Ministrys of Health and Environment, MSF, WHO and CDC** to specify these recommendations in accordance with Zamfara State practices. This advice is provided to the **Ministry** to incorporate procedures and practices into the construction activities and provide appropriate oversight. **Blacksmith** and **TerraGraphics** will maintain on-site presence during the construction period for the convenience of the **Ministry**.

Site Map

Figure 2 shows the Site, Site Boundaries and Limits of Construction, and key features. This base map will be used to support the excavation plan and Project management activities.

Security

Security of the Site is the responsibility of the **Ministry**. The **Ministry** will prevent unauthorized access of the public to the site and secure the site boundaries. The **Ministry** will provide all necessary health and safety equipment and training for Ministry representatives. Security of equipment on the Site is the **Ministry's** responsibility. **Blacksmith/TerraGraphics** representatives shall be responsible for the security, health and safety, training and equipment of **Blacksmith/TerraGraphics** personnel and equipment used on-site.

Site Access

Site Visitors: Site Access will be controlled by the **Ministry**. Only authorized personnel will be granted access to the site and all visitors will be briefed regarding the hazards on the site and the precautions that must be undertaken to safely visit the area.

Site Boundaries and Limits of Construction: All construction and staging activities shall take place within the limits of construction. Best Management Practices (BMPs) shall be employed to prevent contaminant migration beyond the construction limits. The **Ministry** will be responsible for all traffic and access control and to retrieve any Site-related contaminated material that migrates beyond the limits of construction.

Controlling Contaminant Migration

The **Ministry** will institute **Best Management Practices (BMPs)** (e.g. careful excavation, misting and excavation sequencing) to prevent tracking, runoff and dust. Excavations and disturbed areas must be stabilized until final placement of clean cover materials.

Dust Control: The **Ministry** shall execute Work by methods that minimize raising dust from construction and material handling operations.

On-site Water Supply: Dust control should include water spray or misting and attentiveness to excavation, loading, and transport practices. The **Ministry** will provide water and controllable water application. The **Ministry** shall water the site, as necessary, to control dust conditions to prevent airborne dust from dispersing into the atmosphere. The **Ministry** shall control excess water from dust control application to avoid generating mud resulting from excess water.

Erosion and Sediment Control: The **Ministry** shall identify methods for controlling migration of contaminated soils during construction. **Ministry** shall apply work sequencing to avoid contaminating clean barriers.

Runoff Diversions: There will be a temporary berm and trench excavation and placed on all sloped excavation areas to control recontamination as required in case of a rain event. The work will be sequenced in such a manner that trucks and equipment will not track or re-contaminate clean areas.

Tracking Control: Vehicle tracking should be controlled by limiting the site access points (entrances), providing for vehicle decontamination, and a clean access road.

Cleaning truck beds prior to hauling clean soils. Truck beds will be swept clean prior to hauling clean materials on the site.

Preventing Recontamination: Excavations should include a minimum of 5 cm surface soil removal to assure a clean surface remains for replacement. The clean surface should be verified by XRF, following excavation and prior to replacement. BMPs and excavation sequencing should be employed to protect exposed clean surfaces during construction activities. If construction activities contaminate areas previously cleaned as part of this project, the **Ministry** is responsible for replacing the cover materials.

Health and Safety

Blacksmith and **TerraGraphics** will conduct a health and safety discussion for the **Ministry** and personnel prior to commencing excavation and removal of waste from the Site. This discussion will include a review of the Site Control Plan, Excavation Plan, and Disposal Plan, and the recommended hygiene, health and safety, and decontamination practices to be employed during the Project.

Facilities will be provided by the **Ministry** for workers to change clothes, wash and clean footwear prior to leaving the site. The **Ministry** shall supply ample potable water on-site for hygiene and drinking water. First aid kits suitable for response to industrial accidents and heat exhaustion shall be maintained on-site.

Blacksmith and **TerraGraphics** will provide coveralls and dust control masks for workers. **The Ministry** will provide pre-and post-construction blood lead testing for on-site personnel. The **Ministry** will be responsible for all additional health and safety equipment.

The **Ministry** and **Blacksmith/TerraGraphics** will periodically review health and safety measures and corrective measures shall be promptly applied.

See the Health and Safety Plan

Key Equipment / Personnel

The **Ministry**, with the advice of the **Blacksmith** and **TerraGraphics**, will develop and maintain a list of equipment and personnel necessary to carry out the Project. The appropriate equipment and personnel shall be on-site as required by Project activities. The **Ministry and Blacksmith** will coordinate to provide all equipment, supplies, personnel and support requirements necessary to undertake and complete the Project. **Blacksmith** and **TerraGraphics** will provide their own supplies and equipment and the use of and XRF sampling device during the cleanup startup activities until **Blacksmith** and **TerraGraphics** leave the site.

ZAMFARA VILLAGE EXCAVATION AND CLEAN SOIL REPLACEMENT PLAN (Concrete Option)

Prepared by TerraGraphics Environmental Engineering, Moscow, Idaho, USA

1.0 INTRODUCTION

This document is titled the **EXCAVATION PLAN** and provides the cleanup protocol, personnel and equipment requirements, and preliminary quantity estimates associated with the excavation and clean soil and concrete replacement aspects of the health response for the five villages scheduled for remediation in October to December 2010.

Together with the **SITE CONTROL PLAN, LOGISTICS AND DISPOSAL PLAN**, and **HEALTH AND SAFETY PLAN**, these four documents constitute the controlling protocols, procedures and resource requirements for site remediation.

1.1 PRE-EXCAVATION ACTIVITIES

Prior to excavation, each village will be mapped and all outside contaminated areas and contaminated compounds will be located by GPS, assessed, characterized and a site-specific excavation plan developed. Village mapping consists of identifying all streets, by-ways, compounds, shops, mosques and other buildings with unique identifiers. A master map for each village will be developed. Each site will be tested by XRF and site-specific cleanup drawings developed. These plans are assigned to individual Managers on a daily basis throughout the cleanup.

1.2 DECONTAMINATION APPROACH AND TRAINING

The basic approach to decontamination is to remove contaminated surface soil and wastes from the villages using techniques and procedures familiar to the local population. Extensive soil surveys have shown that the contaminants are largely contained in the top 5 centimeters of surface soils overlaying sub-soils densely compacted by village foot traffic. These contaminated soils can be removed using agricultural tools in an effective manner mimicking village practices. Contaminated soils are bagged in readily available sacks and transported to constructed landfills. The contaminated soils are replaced with clean soils of suitable compaction quality at all excavated surfaces. The following cleanup criteria are applied: all soils greater than 1000 mg/kg (or detectable Hg) are removed and replaced with soils containing less than 200 mg/kg Pb (generally <60 mg/kg Pb). Contaminated soils between 400-1000 mg/kg lead are covered with 8 centimeters of compacted clean soil. Soils in the 400-1000 mg/kg range can be excavated at the Village Cleanup Director’s discretion.

The replacement soils offer a low-lead soil and dust exposure source to children, act as a barrier sub-surface contaminants, and dilute any contamination remaining following excavation. This procedure is applied inside the home compounds and in exterior locations inaccessible to mechanical equipment. Process wastes from former mining and mineral extraction locations are excavated by heavy equipment, if accessible, and disposed of in the landfill. These areas are also returned to grade with compacted clean soils.

Wastes and contaminated soils are placed in a constructed landfill, compacted and covered with a one-meter cap of compacted local clays and suitable cover material. The buried material is largely low concentration lead contaminated soils (generally .1 to 1% lead on average), with individual loads ranging to 10% lead. Some mineral processing wastes exceed 10% lead. These wastes are inorganic weathered oxidized galena compounds, likely of low solubility in natural environments and typical pH. The landfills are constructed dense clays with low permeability, minimizing the probability of significant leachate production, transport, or release to the environment, thus avoiding the need for liners.

1.3 IMPLEMENTATION AND TRAINING

Implementation of the **EXCAVATION PLAN** will be in accordance with the Project Schedule for each village. Excavation and training for soil remediation will commence at an outside location where crushing and grinding took place. Training and implementation will proceed as follows:

Soil Removal Crew 1 and Clean Soil Crew 1 will be trained at this site on day 1 with the other crews observing.

On day 2 Soil Removal Crew 1 will proceed to an interior compound and receive training on the inside cleaning procedures. Soil Removal Crew 2 and Soil Removal Crew 3 and Clean Soil Crew 2 will be trained on an outdoor site on day 2.

On day 3, Clean Soil Crew 1, Concrete Floor Crew 1, Soil Removal Crew 2 and Soil Removal Crew 3 will be trained indoors and Soil Removal Crew 4 and Soil Removal Crew 5 will be trained on an outdoor site.

On day 4, Clean Soil Crew 2, Concrete Floor Crew 2, Soil Removal Crew 4 and Soil Removal Crew 5 will be trained indoors and Soil Removal Crew 6 will be trained at an outdoor site.

It is anticipated, when fully trained, Soil Removal Crews should proceed at an average production rate of 2 to 3 compounds per day. One Soil Removal Crew will complete the outside sites. Sequencing of Indoor training of the Crews can be delayed, if necessary, with Soil Removal crews continuing outside removals until indoor training can be accommodated.

This is an aggressive schedule and will require the Crew Managers and international advisors to stay at Bukkuyum and Anka during the Project. Supervisors will likely be stationed in Bagega for the outlying villages.

2.0 PERSONNEL

2.1 OVERSIGHT PERSONNEL / MANAGERS / SUPERVISORS

Decontamination Program Manager. *Ministry of Environment* - There will be one Cleaning Program Manager with full authority over all Crews executing the Cleanup.

Assistant Program Manager. *Ministry of Environment* - There will be one Assistant Program Manager with full responsibility to deliver and distribute all Local Government Area (LGA), Ministry Staff, and necessary equipment to the villages by start of work each day.

Village Cleanup Directors. *International* – There will be two Village Cleanup Directors with full responsibility to direct and coordinate Village Crew Operations, one Male and one female.

Village Cleanup Directors Assistants. *Ministry of Environment* – There will be two Assistant Village Cleanup Directors accompanying the Village Cleanup Directors with the specific responsibility to build this capacity to direct and coordinate Village Crew Operations within the Ministry, one Male and one female.

Resident Project Representatives (RPRs). *International* – Each village shall have two international Technical Advisors, one male and one female, that will oversee development and assignment of the site specific cleanup plans, and provide general technical assistance and guidance to the Crew Managers.

Construction Equipment Manager. *International* - The Construction Control Manager will be responsible to execute the Site Control Plan and shall oversee and provide technical assistance and guidance for Landfill Construction, Clean Material Supply, Equipment Management and Disposal Team operations

Cleanup Crew Managers. There will be six Cleanup Crew Managers per village, four male and two female, from the Zamfara State government. They will be advised by the International Technical Assistance Team RPRs.

Cleanup Team Supervisor. *Ministry of Environment* - There will be 7 Cleanup Crew Supervisors, preferably 2 female. Specific duties will be to assist in excavation and soil replacement and laundry and food operations.

2.2 CLEANUP CREWS

Village Workers - There will be six types of Crews involved in Excavation of Contaminated Soils and Replacement of Clean Soil as follows. Village Cleanup Directors may re-configure the crews as required during the course of the cleanup.

1. **Outside Excavation Crew, one alternating Crew**
2. **Inside Excavation Crews, three Crews**
3. **Soil Replacement Crews, two Crews**
4. **Concrete Floor Crew, one crew**
5. **Contaminated Soil Disposal Crews, two crews**
6. **Laundry and Food Crews**

The Excavation Crews will work only with contaminated soils. The Soil Replacement Crews shall work only with clean materials and equipment. The equipment shall be maintained separately at all times and not used interchangeably. If absolutely necessary, equipment can be moved from one crew to another **only** after decontamination with a clean soil bath.

All Excavation Crews and Clean Soil Replacement Crews will be trained at an Outside Site. Four crews shall be trained. The Crews will be transferred to Indoor Excavation and trained a second time for Inside Cleaning. One Outside Excavation Crew shall complete the Outdoor Sites after all Crews are trained.

Clean Soil Crews will also be trained at Outside Sites first and then a second time at an Inside Compound.

The Contaminated Soil Disposal Crew will work only with contaminated equipment and ensure that all contaminated soils are properly transported and disposed of at the landfill or stored at the Contaminated Soil Staging Area. One crew will work at the landfill unloading sacks. One crew will work in the village loading sacks into the disposal vehicle.

2.2.1 Outside Excavation Crew: One permanent crew of five locally trained village residents will excavate contaminated soils from the former grinding/crushing sites and contaminated streets.

Each Outside and Inside Excavation Crew shall be equipped with 5 hoes, 3 shovels, 2 wheelbarrows, 3 head pans, 1 knapsack sprayer (new and unused), 6 20-25 liter buckets and 2 20-25 liter water supply cans, supply of bags, stiff bristle brush, four soft brushes, 2 mops, cleaning rags, and Health and Safety supplies.

2.2.2 Inside Excavation Crews: The first five crews trained outside will move to inside training after successfully completing one outside site. These crews will use the same equipment issued to them for the outside cleaning. They will be escorted inside by the female Cleaning Crew Managers and will work under their supervision.

2.2.3 Soil Replacement Crews: Three Soil Replacement Crews shall be trained. Each Crew shall have five local village residents. These crews shall only handle clean materials and always work in decontaminated areas. Use of protective gear shall not be required but dust masks should be available, if desired.

Each Soil Replacement Crew shall be equipped with 3 hoes, 3 shovels, 2 wheelbarrows, 1 rake, 3 head pans, 1 knapsack sprayer (new and unused), , 1 20-25 liter water supply can, a supply of bags, and Health and Safety supplies.

Managers may reconfigure the crew equipment with the approval of the Village Cleanup Director.

2.2.4 Concrete Floor Crews: There will be one concrete floor team, if the concrete floor option is selected. The team shall consist of a mason and mason's assistant.

Each team will be equipped with one wheelbarrow, 2 hoes, 2 shovels, 2 headpans, 4 trowels, 2 pairs rubber boots, 1 knapsack sprayer (new and unused), a roller and/or impact compactor, 3 20-25 liter water supply cans,), 3 20-25 liter buckets, and Health and Safety supplies.

2.2.5 Health and Safety Requirements: Basic safety standards including adequate Personal Protective Equipment (PPE) must be implemented. The excavation and disposal crews will be outfitted with gloves, washable work suits and dust masks. These items must be available daily. Each team will receive basic instruction regarding hygiene and safe work practices. Because of the heat, ongoing exposure in the community, urgency of the situation, and limited supply; use of safety equipment may be significantly modified to accommodate the local environmental conditions. Respiratory protection is required for excavation and disposal personnel. Masks will be available for the clean soil crews, but use is not required for those working with clean soil.

Crew managers will be responsible for ensuring that excavation and disposal crew members wash before eating, change clothes, bathe and wash shoes, before leaving the site for the day, and that their contaminated clothing is turned in at the end of every day. Laborers must wash, change clothes and clean shoes before returning to their homes. A bathing and laundry facility will be constructed on-site. Wash water and clean drinking water must be made available every day. Contaminated water will be contained and evaporated each day in a small settling basin. Sediments will be collected and disposed of in the landfill.

3.0 OUTSIDE REMEDIATION PROCEDURE

3.1 STEP 1 - XRF Survey

The XRF will be used to delineate the contaminated areas. The areas will be marked.

3.2 STEP 2 – Compound Excavation Preparation

Compounds must be made ready for excavation the day prior to the start of work. The family must be informed that excavation will begin the following day and it should be explained what the work will involve. Livestock will need to be removed. Children will need to play elsewhere for the day and **must not be allowed in the compound at any point during excavation**. Women will be instructed to do the following before excavation work begins the following morning:

- Remove all bedding, cooking pots and pans, mats used for sleeping or sitting from all rooms. Even rooms not slotted for excavation or backfill should be cleaned.
- Cement areas must be swept and SCRUBBED thoroughly with soap.
- All clothing, bedding, cooking pots and pans, mats used for sleeping or sitting need to be washed with soap.
- After all items are cleaned, they must be returned to **clean** rooms, but NOT rooms with dirt floors slotted to be excavated or backfilled.
- Everything in the compound must be moved for excavation (stools, mortar/pestle, firewood, animals).
- The well should be covered with a clean cloth or sheet of metal during excavation.

3.3 STEP 3 – Removal of Contaminated Soil

The Outside Crew will begin excavation at the inside of the site away from the street access point. Five centimeters of soil will be removed by working backwards toward the street. No foot traffic will be allowed on the excavated surface. A light mist of water shall be applied to the contaminated soil to minimize dust. This should be metered to eliminate visible dust, but not create muddy conditions.

Contaminated soil will be placed by shovel into a wheelbarrow or bags. Wheel barrows contents will be loaded directly into a truck or small staging pile. Staging piles shall be loaded into a truck within 2 hours. If no truck is available contaminated soil must be placed in bags, sealed with twine and staged into a secure area until transported to the repository.

The excavated surface will be tested by XRF any remaining contaminated soil detected will be removed by excavation and the excavated surface retested. All bags and staging piles shall be removed to a secure location.

The staging area will be excavated last and tested by XRF until clean. The adjacent street should be tested and cleaned, provided there is no significant chance of recontamination by work on adjacent properties.

The **Disposal Team** shall remove all Bags and truckloads of Contaminated Soil to the ***Disposal Area*** or ***Contaminated Soil Staging*** Area each day. No bags should remain in the village overnight and children should be restrained from accessing the bag storage area during the day. (See the Disposal Plan and Site Control Plan).

The site will then be released to the Soil Replacement Crew.

3.4 STEP 4 - Clean Soil Replacement

Clean soil replacement shall be done only by the Clean Soil Replacement Crews. Replacement of clean soil shall not occur until the risk of contamination from adjacent properties is minimal. Clean soil shall be brought from the storage pile by wheelbarrow, loader, or truck. This equipment must be used only for clean material, never for de-contamination or excavation. Transfers of equipment can occur, if required, by thorough cleaning, but should be avoided.

Clean soil replacement shall begin away from the street and proceed toward the entrance taking care not to allow foot traffic on clean soil until the entire site is covered. Clean soil should be obtained from the storage piles only and should be a mix of the clay and gravel soils as directed by the supervisor. Eight (8) centimeters of soil shall be placed (excavation depth plus 3 cm. to allow for compaction). If an excavation depth greater than 5 cm is found to be necessary, more clean soil backfill will be required.

The site can then be compacted by using a roller or impact compactor and/or footwork. Crew members should ensure their feet are not contaminated before they walk on the clean surface. Additional clean soil may be added during compaction to fill depressions and promote drainage. Water may be added, using the knapsack sprayer, to minimize dustiness during replacement and assist with compaction. Care should be taken to avoid creating muddy conditions. No mining or processing activities should be allowed on these sites in the future.

3.5 STEP 5 - Disposal of Contaminated Soil

Contaminated soils are disposed of at an engineered landfill that will be covered and closed at the completion of the village decontamination process.

See the Logistics and Disposal Plan

3.6 STEP 6 - Records and Equipment Storage

Site Records and Closure: The supervisor shall maintain a log and record the Site Location, Sketch of Features, Area (sq m), amount of material removed – (# of bags and # of wheelbarrows of contaminated soil), amount of clean soil used (# of bags and # of wheelbarrows of clay and gravel), XRF time and initial lead readings, Excavation Crew start and finish time and Crew Number, XRF clearance time and readings, and Replacement Crew start and finish time and crew number. Managers shall also record all crew members name, identification, duty and time worked each day.

Equipment Storage: At the end of the day the Excavation Crew equipment shall be brushed clean at a designated ***Cleaning Location*** and stored in a secured ***Equipment***

Storage Location for the night. This equipment should not be stored in a residential compound unless specifically approved by the Program Manager with appropriate precautions to avoid contamination. The Excavation Crew workers should change clothes, store their work clothes securely, wash, and wear clean clothes home. Excavation Crews work clothes should be cleaned at the ***Cleaning Location*** on a periodic basis. Soil Replacement Crew equipment shall be stored separately from the Excavation Crew equipment and may be stored at residential compounds with the approval of the Program Manager.

There should be a designated Equipment Manager at each site who is responsible for equipment inventory each day. The Equipment Manager shall track the supplies each crew takes each day and make sure that every item is returned at the close of each work day.

See the Site Control Plan for additional authorities and responsibilities.

4.0 INSIDE COMPOUND CLEANING PROCEDURE

4.1 STEP 1 - XRF Testing

The XRF will be used to delineate any non-contaminated areas. The areas should be marked and avoided, and monitored during cleaning. All other areas will be presumed contaminated.

4.2 STEP 2 – Temporary Relocation of Family Members

Children should be relocated to another compound and not allowed to be in the area during cleaning. Animals should be moved out of the compound, if possible. Some women may remain in the residence as required to assist with cleaning of personal effects and animal management.

4.3 STEP 3 - Designate Operational Areas and Plan Sequence of Removal

Areas within the compound need to be designated for i) containment of debris and animals, ii) cleaning of personal effects, and iii) management of persons remaining in the home. A plan should be developed to sequence the cleaning from the rear of the compound to the main entrance.

4.4 STEP 4 - Sweeping and Brushing of Walls and Floors

All exterior walls and horizontal surfaces in the compound should **be** lightly brushed to dislodge adhered dust and let it fall to the floor. All floors should be swept to remove easily accessible dusts and small debris. This dust and small debris should be placed in a sack and sealed, and staged in the staging area.

4.5 STEP 5 - Decontamination of Debris and Animal Containment Areas.

A small area(s) should be designated where debris and animals can be contained during the cleaning. These areas should be pre-cleaned:

i) lightly brush any adjacent walls and horizontal surfaces to dislodge adhered dust to the floor. Sweep this area and collect the sweeping in a bag.

ii) remove 5 cm of soil starting at the wall and moving toward the center of the compound in the same manner as the outside removal. The area should be XRF'd and residual contaminants removed.

iii) collected debris and animals should be placed on this clean surface, with a modest effort to dislodge dust and dirt before moving. Water spray may be used, but do not create mud.

4.6 STEP 6 – Removal of Contaminated Soils

The Inside Crew will begin excavation at the rear of the compound away from the entrance or street access point. Individual rooms will be cleaned first. Five centimeters of soil will be removed by working backwards toward the entrance. No foot traffic will be allowed on the excavated surface. A light mist of water shall be applied to the contaminated soil to minimize dust. This should be metered to eliminate visible dust, but not create muddy conditions.

Alternatively, all rooms and/or veranda sleeping areas could be provided with concrete floors, encapsulating the contaminants below the cement and providing a cleaner surface for children and mothers. If the room is to be cemented, only sweeping is required. This will reduce the excavation quantity, landfill and clean material requirements and, speed the excavation procedure. Concrete floors should be 6 to 10 cm thick on compacted base.

After the rooms are cleaned; open areas, connecting pathways, and the central compound area should be cleaned. The cleaning should proceed from the areas most remote from the main entrance. Five centimeters of soil should be removed with the hoes, working backwards, away from the cleaned rooms, and toward the entrance of the compound. Designated areas should be re-tested and incorporated into the procedure if additional removal is required.

Contaminated soil will be placed by shovel into a wheelbarrow, head pans or bags. Wheel barrow and head pan contents will be loaded directly into a truck or small staging pile. Staging piles shall be loaded into a truck within 2 hours. If no truck is available contaminated soil must be placed in bags, sealed and staged into a secure area until transported to the repository.

The excavated surface will be tested by XRF. Any remaining contaminated soil detected will be removed by excavation and the excavated surface retested. All bags and staging piles shall be removed to a secure location. The room should be secured with tape, etc. to prevent entry until the removal is complete.

The staging area will be excavated last and tested by XRF until clean. The adjacent street should be tested and cleaned, moving away from the entrance to the extent of contamination delineated by XRF testing.

The **Disposal Team** shall remove all Bags and Truckloads of Contaminated Soil to the ***Disposal Area*** or ***Contaminated Soil Staging Area*** (See the Disposal Plan and Site Control Plan).

The Compound will then be released to the Concrete Floor Crew

4.7 STEP 7 - Concrete Bedroom and Sleeping Veranda Floors

Because lead contamination is difficult to remove from aged concrete floors, it is recommended to add 3-5 centimeters of fresh concrete to existing concrete surfaces. surfaces. This work will be undertaken by the Concrete Floor Team. Solid surfaces will be swept and any sweepings placed in a contaminated soil bag. If the surface is suitable for concrete addition, the floor may be framed and poured. Sub-standard concrete base can be removed, if necessary. These materials should be disposed of in the same manner as contaminated soils.

i) lightly brush any adjacent walls and horizontal surfaces to dislodge adhered dust to the floor. For existing concrete surfaces, sweep this area and collect the sweeping in a bag. Sweeping is not required for soil surfaces, although the brushing of walls should be done before pouring concrete.

ii) frame the area as necessary to accommodate 7-10 cm of concrete, as agreed to by the head of the household,

iii) mix, pour and compact concrete. Finish as required. Sand aggregate should be tested with the XRF prior to mixing, especially if it is obtained from a river area anywhere near (downstream of) ore processing.

iv) provide access barriers to allow proper drying time.

v) Apply water mist as required during curing process. Water and sweep clean before allowing resident to return personal effects.

4.8 STEP 8 - Clean Soil Replacement

Clean soil replacement can be accomplished as the concrete and personal effects cleaning is on-going, if approved by the female RPR.

Clean soil replacement shall be done only by the Clean Soil Replacement Crews. Clean soil shall be brought from the storage pile by wheelbarrow or truck (or clean bag if necessary). This equipment must be used only for clean material, never for de-contamination or excavation. Transfers of equipment can occur, if required, by thorough cleaning with water and rinsing, but should be avoided).

Clean soil replacement shall proceed in the same order as removal. The rooms should be replaced first. The gravel soil should be used and compacted to a hard floor condition in dirt floor rooms. The outside soil replacement should begin at the rear of the compound and proceed toward the entrance to the compound away the street taking care not to allow foot traffic on clean soil until the entire site is covered. Clean soil should be obtained from the storage piles only and should be a mix of the clay and gravel soils as directed by the supervisor. Eight (8) centimeters of soil shall be placed (excavation depth plus 3 cm. to allow for compaction).

The site can then be compacted by using a roller or impact compactor and/or footwork. Crew members should ensure their feet are not contaminated before they walk on the clean surface. Additional clean soil may be added during compaction to fill depressions and promote drainage. Water may be added, using the knapsack sprayer, to minimize dustiness during replacement and assist with compaction. Care should be taken to avoid creating muddy conditions. No mining activities should be allowed on these sites in the future.

4.9 STEP 9 - Disposal of Contaminated Soil

Contaminated soils are disposed of at an engineered landfill that will be covered and closed at the completion of the village decontamination process.

See the Logistics and Disposal Plan

4.10 STEP 10 - Records and Equipment Storage

Site Records and Closure: The Crew Manager shall be responsible for maintaining a log with the following information for each compound he works in: XRF excavation check times and results; crew start and finish times; any problems with crews, equipment, work; general observations; equipment used at the compound; crew member names, duties, and hours worked. This should be done daily and rigorously.

Equipment Storage: At the end of the day the Excavation Crew equipment shall be brushed clean at a designated ***Cleaning Location*** and stored in a secured ***Equipment Storage Location*** for the night. This equipment should not be stored in a residential compound unless specifically approved by the Program Manager with appropriate precautions to avoid contamination. The Excavation Crew workers should change clothes, store their work clothes securely, wash, and wear clean clothes home. Excavation Crews work clothes should be cleaned at the ***Cleaning Location*** on a periodic basis. Soil Replacement Crew equipment shall be stored separately from the Excavation Crew equipment and may be stored at residential compounds with the approval of the Program Manager.

See the Site Control Plan

5.0 CONTAMINATED BAG EXCHANGE PROGRAM

The surface soils and dusts will be excavated and placed in bags. A supply of clean bags will be obtained in Gusau and transported to the site. The villagers will be asked to bring any bags used in any aspect of mining to a central collection point. These bags will be placed in a secure location and the villagers will be provided clean bags to use in their household activities and cautioned not to use those for mining purposes.

The mining bags turned in by the citizens, if in suitable condition, will be used to collect contaminated material during the removal and disposed of during the cleanup. Additional bags will be required for this purpose. After a compound is cleaned, all bags will be replaced a second time. The recovered bags will be used for contaminated soil transport and storage. All bags used in mining or for contaminated soil will be disposed of in the landfill.

6.0 EQUIPMENT REQUIREMENTS

6.1 PERSONNEL AND EQUIPMENT TRANSPORT

Two air conditioned 4x4 vehicles in good working condition with drivers capable of transporting four individuals and light equipment and supplies will be required through out the cleanup effort for each village in operation. Drivers and vehicles will be required to stay in the same location as the MOE managers and International advisors.

6.2 CLEANUP CREWS EQUIPMENT NEEDS

The Table below provides a list of the quantities and types of equipment estimated to be required for the remediation of each village. This includes equipment, cement, supplies, food, and construction of laundry, cooking, washing and storage areas.

Crew Materials and Supplies List Per Village

Basis:

Item	**Quantity**	**Unit Cost**	**Total**
Hoes	20	500	10000
Shovel	15	1500	22500
Wheelbarrow	20	8000	160000
Head Pan	20	900	18000
Sacks	6000	70	420000
Rakes	6	400	2400
Digger	6	1200	7200
Knapsack Sprayer (new, unused)	7	5000	35000
Paint (5 litre Green)	10	1000	10000
Paint (5 litre Red)	10	1000	10000
Paint Brush (2")	10	100	1000
Face Masks	1000	200	donated
Heavy duty gloves	100	100	10000
Rain Boots	20	1500	30000
Trousers	40	500	20000
T-Shirts	40	600	24000
Basin for bathing	50	1500	75000
Large Basin for Laundry	4	1300	5200
Notebooks	12	300	3600
Pens	10	300	3000
Transport			35000
Total			**901900**
Construction			
Laundry			20000
Cooking area			5000
Washing area			20000
Supply room sec.			5000
Total			**50000**
Cement	**500**	**1650**	**825000**
Food & Consumables for Workers			
Detergent (Omo)	10	5000	50000
Bathing Soap	300	50	15000
Pure Water	4000	60	240000
Bottled Water	10	1200	12000
Rice	4	10000	40000
Meat	36	500	18000
Spices	50	36	1800
Salt	20	36	720
Groundnut Oil	6	1000	6000
Onions	30	36	1080
Tomatoes	30	36	1080
Total			**385680**
Subtotal - weekly food			80680

6.3 EXCAVATION AND MATERIAL TRANSPORT

6.3.1 Quantity Estimates: The Logistics and Disposal Plan contains preliminary estimates for disposal and clean soil requirements for the five villages. In total, approximately 3200 cubic meters of waste is expected to be excavated from the five villages, generating nearly 4000 cubic meters of material to transport to the four to five landfills. The landfills need to accommodate approximately 3500 cubic meters of consolidated compacted waste. Landfills shall be over-excavated to accommodate all possible waste generated. The material will be largely contaminated soil with lead concentrations averaging less than 1% 1ead, but ranging to greater than 10% lead in some locations. There will be 100 to 200 cubic meters of high concentration wastes from washing operations or ore processing, generally 3-5% lead from washing (with significant mercury levels exceeding 100 to 1000 mg/kg Hg. Un processed ores will exceed 10 % lead in limited quantities.

Previous experience indicates required clean soil estimates average 150% the *in-situ* volume of contaminant soil removed. As a result, approximately 4500 cubic meters of clean soil will be required. These soils will be generated from approved borrow areas and excavation of the landfills and staged in strategic locations in the villages to facilitate replacement operations. All clean soils are tested by XRF prior to excavation and placement. Low permeability clays encountered in landfill construction shall be retained for cap material during landfill closure.

Two bags of cement will be allocated to each compound undergoing remediation. Precise estimates will be developed following mapping of the villages.

6.3.2 Mechanical Equipment Requirements: An excavator capable of digging a five meter deep trench will be required on site to develop the landfill and clean material supply.

One or two tippers (dump trucks) will be required to move clean soils from the borrow areas and transport wastes to the repository.

On on-site utility pickup (Canter) should be available all day to move materials on site.

A small payloader will be required to facilitate loading the tippers and close the landfills.

Facilities to deliver cement and mix concrete on site (i.e., regular transport of cement and suitable aggregate.

Four-wheel drive support vehicles shall be provided to ensure that heavy equipment is properly maintained and efficiently mobilized and sequenced.

See the Logistics and Disposal Plan

ZAMFARA LOGISTICS AND DISPOSAL PLAN

Phase 2 Village Cleanups – September to December, 2010

STRATEGY FOR CLEANUP OF FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC

Prepared by TerraGraphics Environmental Engineering
Moscow, Idaho, USA
September 5, 2010

1.0 INTRODUCTION

This remediation project (Project) is being conducted by Zamfara State **Ministry of Environment and Solid Minerals (Ministry)**, assisted by **Blacksmith Institute and TerraGraphics Environmental Engineering (Blacksmith and TerraGraphics).** The purpose of the Project is to eliminate excessive exposure to lead contaminated toxic soils located within five villages in the LGAs of Bukkurum and Anka, respectively, Zamfara State, Nigeria. The Project is being conducted in association with UNICEF, MSF, CDC, WHO and the local governments.

The attached memo entitled **SUMMARY OF RECOMMENDATIONS - EMERGENCY CLEANUP STRATEGY FOR FIVE VILLAGES IN BUKKUYUM AND ANKA LOCAL GOVERNMENT AREAS (LGA), ZAMFARA STATE, NIGERIA –LEAD POISONING EPIDEMIC** provides a description of the major health and environmental considerations and the strategy for addressing those concerns. These concerns are addressed in three plans developed in draft form by TerraGraphics and provided to the **Ministry** as recommendations. Those plans are: **a) SITE CONTROL PLAN, b) EXCAVATION PLAN, c) LOGISTICS AND DISPOSAL PLAN, and d) HEALTH AND SAFETY PLAN.**

***This document is the* – LOGISTICS AND DISPOSAL PLAN**

1.1 Methods and Principle Guidelines

Basic Methods: The Project goals and technical approach are similar to the first phase of remediation at Dareta and Yargalma villages in June and July 2010 prior to the rainy season. The basic strategy is removal of lead contaminated soil and replacement with uncontaminated soil using best management practices.

Principle Guidelines:

- The local populations, especially children under five years of age, living in the identified sites will or have already undergone screening tests to determine the blood lead levels (BLLs).
- Those children reporting high blood lead levels will be recruited for hospitalization and chelation therapy by Zamfara health authorities and MSF.
- The homes of these children will require remediation prior to their return from the hospital.
- Remediation plans have been designed in accordance with local population exposures and specific site contamination.
- Remediation options provide for the use of locally sourced materials wherever possible
- Only proven technologies and methodologies familiar to villagers are considered.
- Every effort will be made to involve the local populations in the implementation of the plan, especially in the actual remediation processes.

1.2 Authorities and Responsibilities

This Memorandum includes a written description of:

1. ***management of all onsite personnel, payroll and procurement,***
2. ***management of Project and Site security.***
3. ***management of heavy equipment and supplies;***
4. ***construction and operation of landfills at each of the villages to accept waste from the emergency cleanup project and the ongoing mining operations;***
5. ***collection and transport of contaminated soils;***
6. ***delivery, stockpiling and management of clean materials and cement;***

These duties are the responsibilities of the: **Ministry of Environment Assistant Project Manager** and the **International Construction Equipment Manager.** The division of primary responsibilities reflects the funding source for the activities. The **Ministry of Environment Assistant Project Manager** shall be responsible for the equipment and supplies required by Ministry and LGA personnel and the village excavation and clean soil replacement crews. The **Ministry of Environment Assistant Project Manager** is also responsible to deliver all Ministry, LGA and village personnel to the job site by start of work each day. The **International Construction Manager** shall be responsible for equipment and supplies associated with the contracted heavy equipment and any activities funded by UNICEF monies.

The **Ministry of Environment Assistant Project Manager** shall report directly to the **Ministry Project Manager.** The International Construction Equipment Manager shall report directly to the **TerraGraphics Project Manager.** Both **Construction Managers** will be required to develop individual plans and procedures to support the logistics, heavy equipment, transportation, procurement and personnel requirements of the Project. The Construction Equipment Managers may wish to engage a Contractor to assist with these responsibilities. The following descriptions provide the best estimates of the scope and magnitude of the proposed project, with respect to the six areas of responsibility:

Construction and Operation of Landfills: Repositories will need to be located, designed and constructed to dispose of the wastes generated in the cleanups and from continuing mining operations in the vicinity.

Collection and Transport of Contaminated Soils: Contaminated soils will be delivered to the streets by the Excavation Crews in wheelbarrows, headpans or bags. These materials will need to staged and collected on a routine basis by the disposal crews in the Tipper trucks or Canters and delivered to the landfill.

Development, Delivery, Stockpiling and Management of Clean Materials and Cement: Clean soils will need to be generated from identified borrow sources and stockpiled near the operations for the Replacement Soil Crews use. Facilities for transport and storage of cement and mixing of concrete will be required.

1.3 Village Status Summary

The villages of Tungar Guru and Abare have been visited by remediation personnel, but have not been mapped or characterized to the extent the villages remediated in the last dry season were addressed. An estimated 70 compounds will require remediation in Abare and 30 compounds in Tungar Guru. The villages of Tungar Daji, Sunke and Duza have not been visited. For planning purposes, it was assumed that each village has 50 compounds requiring remediation (approximately the magnitude of the Yargalma pre-remediation effort). These villages will be exceedingly difficult to access and the actual number of compounds and extent of village contamination levels will vary considerably.

The following wastes, materials and construction requirements are expected at each village**:**

Tungar Guru: The corrective actions in Tungar Guru include excavation and removal of approximately 600 cubic meters of toxic waste and lead contaminated soils. Approximately 300 cubic meters of contaminated soils will be excavated from within the residential compounds of the village. About 150 cubic meters of contaminated soils are found near former ore crushing and grinding sites, village streets and common areas and about 150 cubic meters from processing areas. The excavation will produce approximately 780 cubic meters of waste soil and significant volumes of waste bags and debris. These soils and wastes will be transported from the village and placed in an engineered landfill to be constructed near the ongoing mineral processing areas near each village. The landfill will also be used to dispose of wastes generated by the mineral processing activities. The landfill should be overdesigned by +20% to accommodate additional waste and quantity uncertainties.

Contaminated soils will be removed by hand excavation utilizing local labor and construction practices. The excavated surfaces will be covered with clean soils and returned to original conditions, or covered with a protective layer of concrete. Approximately, 800 cubic meters of clean soils will need to be generated and delivered to the site. In addition, approximately 400 50-kilo bags of cement and necessary sand and aggregate to produce 70 cubic meters of concrete must be delivered to the site. Stockpiling and onsite management will be required to not impede the construction schedule.

Abare: The corrective actions in Abare include excavation and removal of approximately 800 cubic meters of toxic waste and lead contaminated soils. Approximately 600 cubic meters of contaminated soils will be excavated from within the residential compounds of the villages. An estimated 200 cubic meters of contaminated soils are found near former ore crushing and grinding sites, village streets and common areas. These soils and wastes will be transported from the village and placed in an engineered landfill to be constructed near the ongoing mineral processing areas near each village. The landfill will also be used to dispose of wastes generated by the mineral processing activities. The landfill should be overdesigned by +20% to accommodate additional waste and quantity uncertainties.

Contaminated soils will be removed by hand excavation utilizing local labor and construction practices. The excavated surfaces will be covered with clean soils and returned to original conditions, or covered with a protective layer of concrete. Approximately, 1100 cubic meters of clean soils will need to be generated and delivered to the site. In addition, approximately 1150 50-kilo bags of cement and necessary sand and aggregate to produce 140 cubic meters of concrete must be delivered to the site. Stockpiling and onsite management will be required may be required to not impede the construction schedule.

Tungar Daji, Sunke, and Duza: These villages have not been accessed, mapped or characterized. These estimates are based on anecdotal information provided by various investigators to the villages last dry season. The corrective actions estimated for each village include excavation and removal of approximately 600 cubic meters of toxic waste and lead contaminated soils. Approximately 500 cubic meters of contaminated soils will be excavated from within the residential compounds of the village. About 100 cubic meters of contaminated soils are found near former ore crushing and grinding sites, village streets and common areas. The excavation will produce approximately 780 cubic meters of waste soil and significant volumes of waste bags and debris. These soils and wastes will be transported from the village and placed in an engineered landfill to be constructed near the ongoing mineral processing areas near each village. The landfill will also be used to dispose of wastes generated by the mineral processing activities. The landfill should be overdesigned by +20% to accommodate additional waste and quantity uncertainties.

Contaminated soils will be removed by hand excavation utilizing local labor and construction practices. The excavated surfaces will be covered with clean soils and returned to original conditions, or covered with a protective layer of concrete. Approximately, 800 cubic meters of clean soils will need to be generated and delivered to the site. In addition, approximately 820 50-kilo bags of cement and necessary sand and aggregate to produce 137 cubic meters of concrete must be delivered to the site. Stockpiling and onsite management will be required to not impede the construction schedule.

2.0 MANAGEMENT OF HEAVY EQUIPMENT AND SUPPLIES

Equipment, supplies, fuel, water and food necessary to support the operation will need to be procured, transported to and maintained on site.

The following heavy equipment is anticipated to be required on-site at each village.

> An excavator capable of digging a five meter deep trench will be required on site to develop the landfill and clean material supply.
>
> One or two tippers (dump trucks) will be required to move clean soils from the borrow areas and transport wastes to the repository.
>
> One on-site canter should be available all day to move materials on site.
>
> A small loader might be considered to facilitate loading the tippers.
>
> A Payloader will be required to facilitate final remediation and landfill closure efforts at each village.
>
> Four-wheel drive support vehicles shall be provided to ensure that heavy equipment is properly maintained and efficiently mobilized and sequenced.

Facilities to deliver cement and mix large volumes of concrete on site will be required (i.e., cement and suitable aggregate).

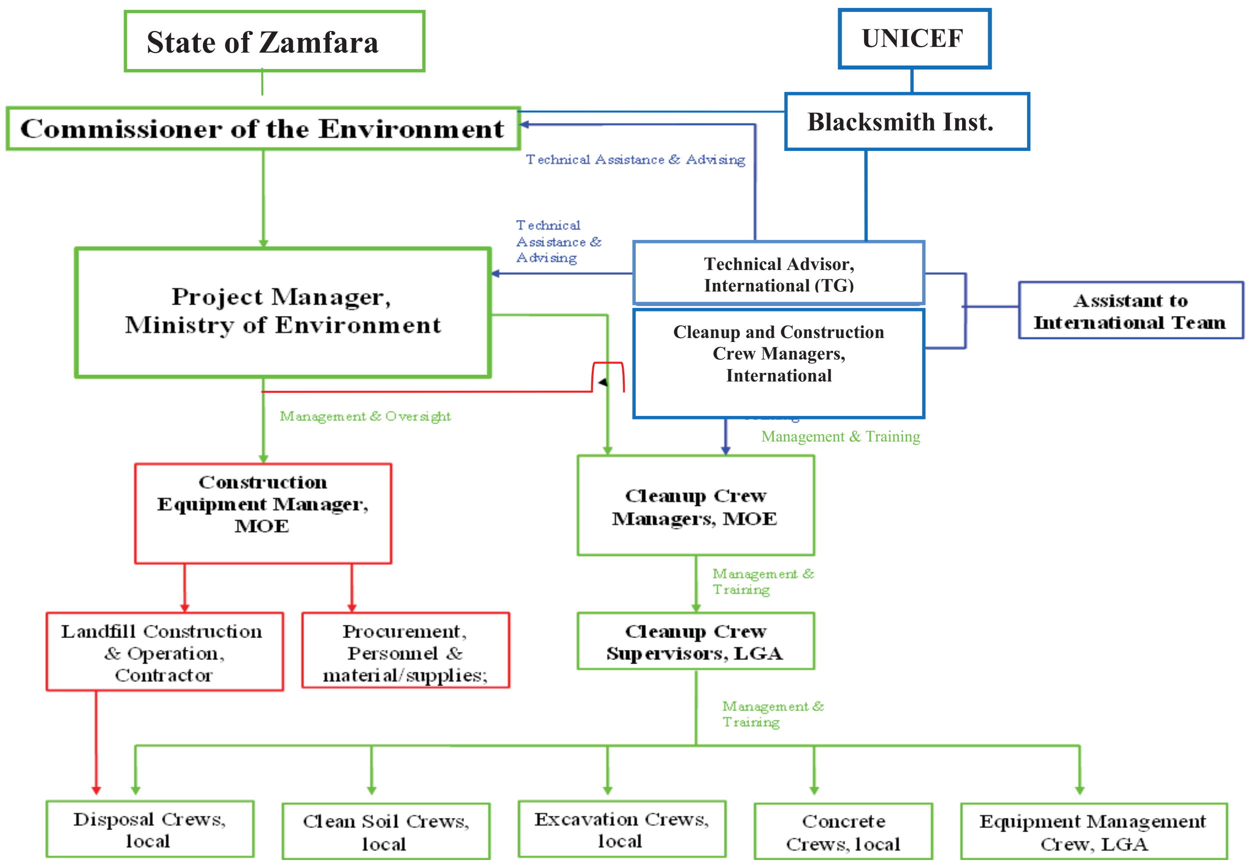
3.0 MANAGEMENT OF ON-SITE PERSONNEL, PAYROLL, PROCUREMENT

The **International On-Scene Coordinator** and **Ministry of Environment Assistant Project Manager** shall be responsible for all personnel management issues for their respective activities.

3.1 Personnel

The following personnel and project structure are anticipated to be employed in the execution of this project:

Figure 1. Project Organizational Structure



Anticipated Project Staffing

Project Management and Oversight

Project Manager: Ministry of the Environment (1)

- Responsible for all Aspects of the Project
- Provide In-country Transportation for the International Team
- Provide MOE/LGA Management and Village Staff
- Provide Transportation for MOE/LGA personnel
- Procure Village Workforce

Assistant Project Manager: Ministry of Environment (1)

- Manage State Contracted Excavation Equipment and Supplies
- Procure personnel, and material/supplies purchases for State Activities
- Manage Site Logistics and Security

- Manage State Payroll and Procurement functions
- Manage Village Laundry, Worker Hygiene, and Food/Water
- Deliver all MOE/LGA and Village personnel to the job sites

Technical Advisors: Blacksmith Project Manager (1)

- UNICEF Contract Administration
- Overall Project Coordination and Management
- Project Budget and Staffing
- International Travel
- MSF, WHO Collaboration
- Project Financing
- Volunteer Coordination

Technical Advisor: TerraGraphics Project Manager (1)

- Provide Technical Assistance and Oversight
- Draft Project Plans
- Manage In-country Technical Programs
- Lead liaison to State of Nigeria representative

Liaison to the International Team – Zamfara State Representative (1)

- Coordinate Internal and State Team Activities
- Advise International Staff re. Implementation of Project Plans
- In-country Liaison with MSF, WHO, State, LGA
- Advise re. Technical Assistance and Direction
- Assist with International Construction Management
- Facilitate Health and Safety Programs

Technical Advisor: International Project On-Scene Coordinator (1)

- On-scene Project Management
- Implement Project Plans
- In-country Liaison with MSF, WHO, State, LGA
- Provide Technical Assistance and Direction
- Direct International Construction Management
- Manage International Health and Safety Programs

Technical Advisor: International Logistician (1)

- Procure Anka/Bukkuyum Lodging Support
- Manage Lodging Compounds
- Procure Heavy Equipment and Supplies
- Manage Heavy Equipment Contracts
- Supervise Timekeeping and Payroll Activities

Technical Advisor: International Project Accountant (1)

- Project Recordkeeping and Accounting

Construction Equipment Manager: International (1)
- Manage Landfill Construction/Operation Crew and any contractor(s) hired to carry out work on landfill
- Procurement, personnel, and material/supplies purchases for UNICEF activities
- Manage Site Logistics, heavy equipment operations and security
- Implement International Health and Safety Requirements

Village Cleanup Directors: International (1 male and 1 female))
- Build capacity of Cleanup Crew Supervisors and Managers to organize and manage future remediation efforts
- Ensure that trainings and initial cleanup efforts adequately meet the remediation protocols
- Train local crews in proper remediation methods
- Oversee Program Implementation in all Villages

Assistant Village Cleanup Directors: International (1 male and 1 female)
- Build capacity of Cleanup Crew Supervisors and Managers to organize and manage future remediation efforts
- Ensure that trainings and initial cleanup efforts adequately meet the remediation protocols
- Train local crews in proper remediation methods
- Monitor cleanup work to assure proper procedures are in use
- Assume full Project responsibilities as International counterparts phase out

Decontamination Personnel

Resident Project Representatives: International (5 female and 5 male))
- Train Cleanup Crew Supervisors to monitor remediation methods
- Monitor cleanup work to assure proper procedures are in use
- Develop and oversee distribution of site-specific cleanup plans
- Oversee XRF Clearance Procedures

Cleanup Village Excavation Crew Managers: MOE (5 female and 5 male))
- Train Cleanup Crew Supervisors to monitor remediation methods
- Monitor cleanup work to assure proper procedures are in use
- Assume full Project responsibilities as International counterparts phase out

Cleanup Clean Soil Crew Managers: MOE (1 female and 1 male))
- Train Cleanup Crew Supervisors to monitor remediation methods
- Monitor cleanup work to assure proper procedures are in use
- Assume full Project responsibilities as International counterparts phase out

Cleanup Village Excavation Crew Supervisors: LGA (5 female and 5 male)
- Manage and organize local labor to carry out cleanup work
- Closely monitor soil removal and replacement procedures and concrete crews

Cleanup Clean Soil Excavation Crew Supervisors: LGA (5 female and 3 male)

- Manage and organize local labor to carry out cleanup work
- Closely monitor soil removal and replacement procedures and concrete crews

Excavation Crew Members: local (5 teams of 30)

- Removal of contaminated soil in accordance with specific directions from Cleanup Crew Supervisors

Soil Replacement Crew Members: local (5 teams of 15)

- Placement of clean soils in compounds and village areas in accordance with specific directions from Cleanup Crew Supervisors

Concrete Crew: local (4)

- Mixing and pouring of concrete inside rooms and at designated outdoor sleeping areas as directed by Cleanup Crew Supervisors

Disposal and Landfill Operations Crew: local (3)

- Removal of contaminated materials from staging area to designated landfill using proper procedures as directed by Cleanup Crew Supervisors

Laundry, Equipment Management and Food/Water Crew: LGA (2)

- Ensure safe use and storage of all equipment
- Ensure that contaminated equipment is not used for clean soil replacement activities

Landfill Construction/Operations Crew: contractor/LGA (2)

- Construction of landfill and oversight of disposal of all contaminated materials

3.2 Management of Project and Site Security

The Ministry Construction Equipment Manager will be responsible for site health and safety, security and site access. The Project will use health, safety, environmental, hazardous waste management and construction practices and procedures specified by the **Ministry**. **Blacksmith** and **TerraGraphics** will recommend techniques similar to those employed at these types of sites in the US. Workers will be informed of the risks associated with the contaminated materials and provided with protective clothing and dust masks. These techniques are in addition to, and intended to supplement, rather than replace, customary construction practices required and implemented in Zamfara State.

The Site should be secured to prevent unauthorized access. All construction and staging activities shall take place within the limits of construction. Best Management Practices (BMPs) shall be employed to prevent contaminant migration beyond the construction limits.

3.3 Procurement and Payroll

Procurement and payroll procedures are implemented through the assistance of the MSF and Emirates of Anka and Bukkuyum. Selection of MOE and LOE personnel are determined by the respective organizations. Village workforce recruitment and selection are accomplished by the local governments and village Chiefs.

4.0 DISPOSAL OF CONTAMINATED WASTES

The purpose of this section is to establish guidelines for locating, constructing, operating, and closing landfills for the Nigeria Lead Remediation Project.

4.1 Collection and Transport of Contaminated Soils and Wastes

Contaminated soils will be removed from the compounds and outside areas by hand labor or machine. Within the compounds, soils will be bagged and secured with twine and the bags conveyed to the street by wheel barrow. Thebe staged at areas designated by the Crew Managers and approved by the RPR. The sacks shall be removed from the staging area each day. At the completion of use of the staging area, it shall be evaluated by XRF and decontaminated accordingly. Care should be taken to keep children away from the staging areas until finally cleaned.

Alternatively, contaminated soils can be conveyed by wheelbarrow to locations accessible to the payloader and loaded into tippers for conveyance to the landfill. Similarly, sites that can be accessed by the payloader can be scraped, dumped into the tipper and taken to the landfill. Any trucks conveying waste must be cleaned prior to use for clean soils.

The sacks shall be loaded by hand labor onto canters and conveyed to the landfill and offloaded according to the landfill operations plan. All disposal personnel shall use respiratory protection and follow the health and safety plan for excavation and disposal personnel.

4.2 Development and Operation of Clean Soil and Landfill Repositories:

Responsibility and Authorities: The **Ministry** is responsible to select and permit appropriate clean soil source and landfill sites; review and approve landfill and clean soil source development and operations plans, and assume responsibility for all long-term operations. The **Ministry** is responsible for all repository activities, including construction, disposal of waste, and closure of the repository. The **Ministry** will provide oversight of engineering, administrative, financial, inspection, and construction management activities. **TerraGraphics** will provide a generic landfill design, operations and closure plan, assist the Ministry in landfill and clean soil repository site selection and development of site-specific of operations plans. **Blacksmith** will engage appropriate construction services to develop the landfills and clean soil repositories, stage clean soils in the villages, dispose of contaminated soils, and assist in decontamination efforts. **Blacksmith** will provide a Construction Manager, who will work under **TerraGraphics** direction, to schedule, coordinate and provide oversight of contract equipment operations.

Wastes to be Disposed: Wastes and contaminated soils are placed in a constructed landfill, compacted and covered with a one-meter cap of compacted local clays and suitable cover material. The buried material is largely low concentration lead contaminated soils (generally .1 to 1% lead on average), with individual loads ranging to 10% lead. Some mineral processing wastes exceed 10% lead. The lead wastes are largely inorganic weathered oxidized galena compounds, likely of low solubility in natural environments and typical pH. The landfills are to be constructed dense clays with low permeability, minimizing the probability of significant leachate production, transport, or release to the environment, thus negating the need for liners.

Preliminary estimates for disposal and clean soil requirements for the five villages include approximately 3200 cubic meters of waste is expected to be excavated from the five villages, generating nearly 4000 cubic meters of material to transport to the four to five landfills. The landfills need to accommodate approximately 3500 cubic meters of consolidated compacted waste. The material will be largely contaminated soil with lead concentrations averaging less than 1% 1ead, but ranging to greater than 10% lead in some locations. There will be 100 to 200 cubic meters of high concentration wastes from washing operations or ore processing, generally 3% to 5% lead from washing (with significant mercury levels exceeding 100 to 1000 mg/kg Hg. Unprocessed ores will exceed 10 % lead in limited quantities.

4.3 Landfill / Repository Siting and Construction Guidelines

The landfills are intended as repositories for lead-contaminated soils that are excavated from the local villages. Each landfill should be constructed with the purpose of sequestering lead-contaminated soils in perpetuity to the extent practicable in a manner that prevents human contact or exposure and minimizes environmental impacts within the area. The landfills are expected to store soils that range from 1000 mg/kg and in excess of 200,000 mg/kg lead.

Due to the highly erosive soils and intense rainfall that is characteristic of Zamfara State, the landfills will be constructed below-grade following these guidelines.

LANDFILL SITING

1. The landfill location shall be determined from a ground reconnaissance of the area within roughly a 2 kilometer radius outside of the local Villages. Several potential sites should be identified that meet the minimum engineering requirements as follows:
    a. Drainage and erosion of the landfill cap from stormwater runoff is the primary concern. Landfills must not be located at the base of any ravines or in dry river channels that are susceptible to washout during flash flooding.
    b. Landfill shall be located within approximately a 2 kilometer radius of the village to minimize haul of clean soil and disposal. Landfill shall be located far enough from village to preclude easy access by villagers.

   c. Landfill should be located on flat terrain accessible to haul trucks and equipment.
   d. The landfill should be sited at a location where the excavated material can be used as a clean soil source.
   e. Areas that are not suitable for farming are preferable.
   f. Test pits should be excavated to the full landfill depth at a minimum of 3 locations to determine subsurface soil characteristics, groundwater, and solid rock outcroppings.
   g. The landfill should be constructed in primarily clay soils. River rock or areas with organics should be avoided.
2. Size
   a. Size shall be determined by estimating the volume of soil that is to be removed within the village and multiplying that value by a Bulking Factor of 30%.
   b. The depth should be 5 meters. This allows for 4 meters of contaminated soil with a 1 meter clean soil/rock cap.
   c. The width should not exceed 30 meters (generally 10 meters) for efficiency in excavating and closing the landfill with either an excavator or payloader.
   d. The length is variable based on the waste volume estimates.
3. Community Input
   a. The Village Chief and local government staff should review the final landfill site and agree on the location. The Chief should determine if color and texture of the borrow soils will be acceptable as clean soil backfill in the compounds.

4.4 Landfill Construction Guidelines

1. The landfill shall be constructed by excavating an open pit with vertical walls. Sloped walls may be constructed if to avoid sloughing or potential failure, if required.
2. An access ramp shall be constructed at one or both ends of the landfill to allow trucks and equipment to access the bottom of the landfill. Short, steep access ramps shall be avoided. The access ramp shall be at least 20 meters long for a 4h:1v maximum grade. Rocky soil shall be placed on the ramp and compacted.
3. Soil excavated from the landfill shall be stockpiled along both edges of the landfill. The stockpiles should be setback at least 1 meter from the edge of the open pit.
4. Access points should be maintained on at least two sides of the landfill to allow end-dumping from the disposal trucks.
5. The bottom of the landfill shall be above the groundwater level. Test pits should be used to determine the groundwater levels.

4.5 Landfill Operations Guidelines

1. The waste material should be placed in 1 meter maximum height lifts working from one end to the other. Each lift should be leveled, graded smooth and compacted by driving/tracking over the waste material with a Payloader or similar heavy equipment. The final lift should be compacted by tracking the entire area with an excavator or payloader until the soil movement under the excavator track is minimal. Typically, 5 passes is acceptable.
2. Waste materials may be emptied into the landfill by dumping from the landfill sides, or by driving into the landfill and unloading or end-dumping materials.
3. Sacks of soil that are disposed of in the landfill should be cut open or ripped using equipment. This will help minimize the void space in the landfill and limit the long-term settlement.
4. Vehicles and equipment are susceptible to becoming stuck in wet clay soils and should be kept out of the landfill if standing water is present.
5. Workers that unload soils by hand or work in the landfill should use Personal Protective Equipment and follow lead-safe work practices.
6. A minimum of 1 meter of clear space should be left between the top elevation of the contaminated soil fill and the adjacent ground surface for the final clean-soil cap.

4.6 Landfill Closure Guidelines

1. Approximately 1 meter of clean soil should be placed as the final lift in the landfill for a cover system.
2. Soil used for the final cover should be selected and sorted during the initial landfill excavation. The cover material should contain a significant amount of aggregate material and contain minimal vegetation that will decompose and result in settlement.
3. The final cover must be compacted with maximum effort.
4. The cover should be compacted in 0.5 meter lifts by tracking the area with five passes with an excavator or similar heavy equipment if an excavator is available on site.
5. The final cover should be generally flat and no more than 0.5 meters higher than the existing ground adjacent to the landfill.
6. It should be assumed the final cover system will not receive any long term maintenance or repair and will be exposed to intense rainfall with flooding. The cover needs to function as a barrier to the contaminated soils and to structurally secure the waste soils in place. The cover must have an armoring effect.
7. Large rocks that can only be moved with heavy equipment should be placed at the landfill corners to identify its limits.

8. GPS readings should be taken at the corners and recorded in a log book.
9. The access ramp must be filled with soil and obliterated to ensure that it does not become a channel for water to drain toward the closed landfill.
10. A meeting with the village Chief should be conducted once the final cover is in place. It should be requested that the Chief declare the landfill area off limits to farming.

Figure 2 shows the generic landfill design to be adapted to site-specific conditions at each village.

5.0 GENERATION AND STAGING OF CLEAN SOILS

5.1 Clean Soil Sources

Clean soil sources should be developed in consultation with the Village Chief. The purpose of and need for the soils should be discussed in detail. It should be emphasized that the soil will be used to cover compounds, streets, open areas and indoor rooms. The soils must demonstrate suitable compaction qualities for these uses, and must meet contaminant guideline (i.e. <200 mg/kg lead, <20 mg/kg arsenic and no detect by XRF for mercury. Generally, the preferred soils will contain significant amounts of small stones and grit to facilitate compaction and runoff of stormwater during the rainy season. If practicable, the clean soil source should be near the landfill location to facilitate equipment use.

5.2 Clean Soil Quantities

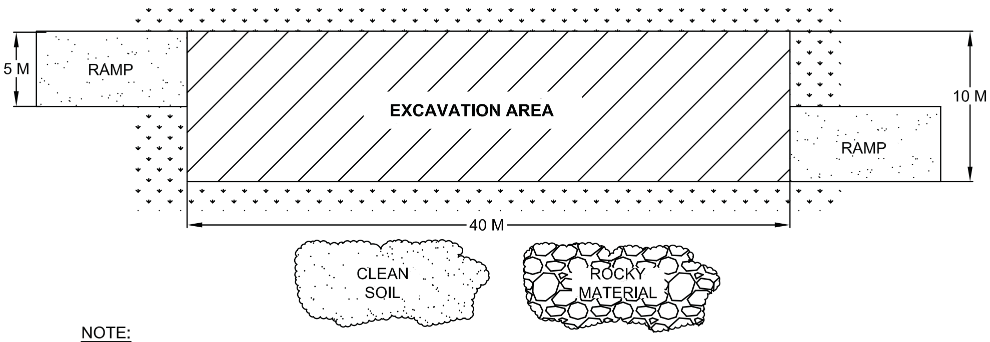
Previous experience indicates clean soil quantities average 150% the *in-situ* volume of contaminants removed. As a result, approximately 4500 cubic meters of clean soil will be required. These soils will be generated from approved borrow areas and staged in strategic locations in the villages to facilitate replacement operations. Spoil material generated in landfill development may also be used for clean soil, provided it meets contaminant criteria and is accepted by the village head as suitable village fill soil. Fine clays should be retained for development of the landfill cap. All clean soils are tested by XRF prior to excavation and placement. The borrow areas should be rehabilitated concurrent with landfill closure.

5.3 Clean Soil Generation and Placement

Clean soil shall be excavated and stockpiled at the source location by the excavator and payloader. One to one and one half the expected need should be excavated to ensure sufficient quantities are available after the excavator leaves the site. Soils shall be transported from the storage area to the village in tipper trucks in 5-10 cubic meter loads and dropped in strategic locations within each village. The Clean Soil Manage shall develop a staging plan in consultation with the Village Cleanup Director and RPR. The Clean Soil Manager shall direct the staging of tipper loads. Material may also be placed by the payloader. Extreme care must be exercised to avoid any damage to structures and endangerment of villagers during this operation. The streets are narrow, uneven, poorly maintained and unaccustomed to heavy vehicles. Traffic control is difficult and many villagers including children are usually present.

The staging locations should be convenient to the compounds and outside areas requiring remediation, avoid contaminated locations, not block village traffic, or surface and waste water drainages. Permission from neighbors to drop soils should be obtained whenever possible. Soils will be removed from the local staging areas by wheelbarrow.

EXCAVATION AND LANDFILL AREA

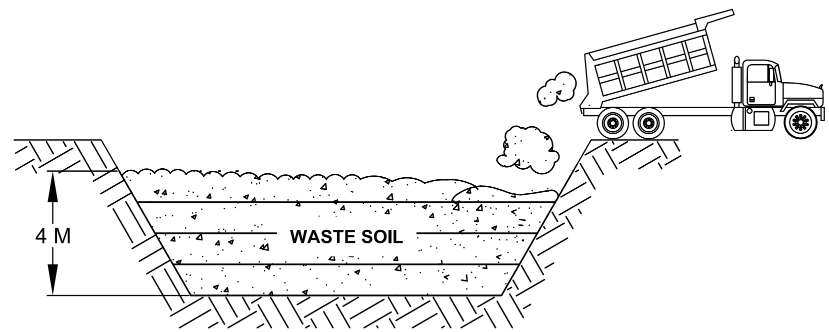


NOTE:

EXCAVATE CLEAN SOIL FROM A 40 METERS BY 10 METERS AREA.

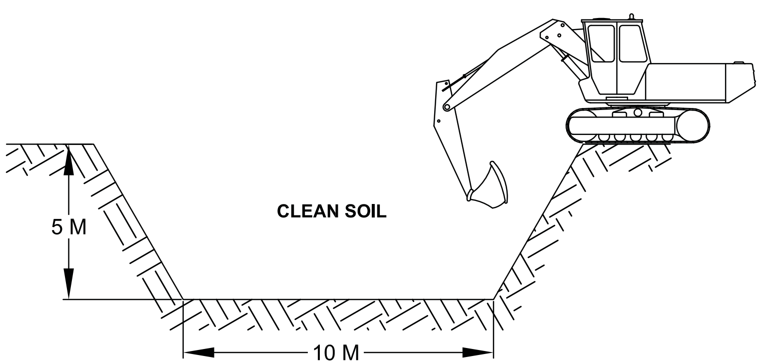
SORT CLEAN SOILS AND LARGER ROCKY MATERIALS INTO TWO PILES.

BACKFILL CONTAMINATED SOIL



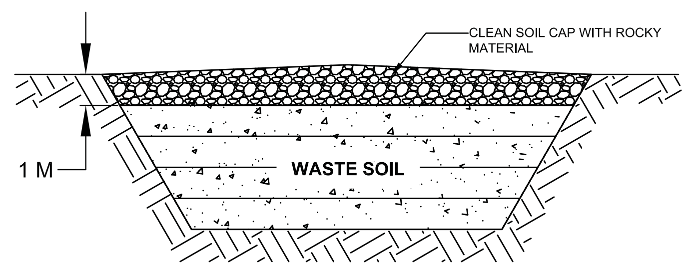
FILL EXCAVATED AREA WITH 4 METERS OF CONTAMINATED WASTE SOIL.

EXCAVATE CLEAN SOIL



EXCAVATE CLEAN SOIL TO 5 METERS DEPTH.

BACKFILL CLEAN COVER MATERIAL



BACKFILL 1 METER OF CLEAN ROCKY MATERIAL OVER TOP OF CONTAMINATED WASTE SOIL,

INSTALL CLEAN MATERIAL COVER AT GRADE OR WITH MINIMAL CROWN AT CENTER.

TerraGraphics Environmental Engineering, Inc.	DRAWN: M. MIRAGLIO	PROJECT NO.: NTN	NIGERIA CLEAN SOIL BORROW PIT AND WASTE DISPOSAL AREA	DATE: 8/27/2010
	ENGINEER: D. FORSETH	SCALE: NTS		SHEET: 1 OF 1

Health and Safety Plan
Zamfara State
Lead Remediation

for TerraGraphics and Blacksmith Institute Personnel

September 2010

Prepared by:

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Health and Safety Policy

TerraGraphics Environmental Engineering, Inc. is committed to creating and maintaining a safe working environment for its employees. With that in mind, this Health and Safety Plan contains selected policies and procedures related to activities conducted with the sampling and remediation of rural villages in Nigeria. The intent of this Health and Safety Plan is to provide local and international personnel easily accessible health and safety references for performing field operations.

It is important to understand how to perform your job duties in a safe way. If you don't know, stop and ask your supervisor or project manager. It is your responsibility as an employee to observe all safety rules and regulations as well as properly use all safety equipment. It is not possible to include specific instructions for every condition or local regulation that you may encounter, so remember that common sense and safety are the underpinnings of this program.

Personnel will be provided with a copy of this Health and Safety Plan. The applicability of this Health and Safety Plan is cumulative to other TerraGraphics policies and procedures regarding health and safety. This Health and Safety Plan should be used in conjunction with Medecines Sans Frontiers (MSF) safety guidance documents (MSF, 2010).

The management of TerraGraphics encourages employees to become involved in the process of creating a safe and healthy work environment, and encourages discussion and input regarding the policies and procedures herein.

This document applies to the Zamfara State Leader remediation project and all volunteers and employees of both TerraGraphics and Blacksmith Institute. TerraGraphics and Blacksmith are responsible for their respective representatives to be aware of and in compliance with these policies.

Section 1.0 Introduction

This Health and Safety Plan (HSP) will cover sampling and remediation activities conducted under the Zamfara State, Nigeria Lead Poisoning Epidemic Program, as well as international travel security and health guidelines. The activities to be performed involve the sampling, removal, and disposal of soils in residential compounds in Northern Nigeria.

Section 2.0 Chemical Hazards

Lead has been identified as the major contaminant in soils, although other heavy metals are also present at concentrations exceeding typical background levels. Soil contamination in the project area has occurred due to mining and ore processing activities.

2.1 Waste Characteristics

Waste Type(s):

Liquid X Solid X Sludge Gas Dust X

Characteristics:

Corrosive X Ignitable Radioactive Volatile

Toxic X Reactive Unknown Other

2.2 Hazard Evaluation

Lead is the major contaminant of concern, but other metals may be found in the soils. Because lead is typically the contaminant found in the highest concentration, it is assumed that controlling the exposure to lead will adequately control exposure to the other metals found in the soils and dust.

2.3 Regulatory Exposure Limits

Occupational Safety and Health (OSHA 29 CFR 1910.1000 - air contaminants) the PEL values reported below are based on an 8-hour time-weighted average concentration, and the National Institute of Occupational Safety and Health (NIOSH) REL value reported below are based on a10-hour time-weighted average concentrations, have all specified daily workplace limits on exposure to metals. See Table 1 for PEL and REL values.

Table 1. OSHA PEL and NIOSH REL Values

Metal	OSHA (mg/m3) (PEL)	NIOSH (mg/m3) (REL)
Lead	0.05	5.0
Zinc (as oxide)	5 (fume) 15 (dust)	5 (dust)
Cadmium	0.005	lowest feasible
Arsenic (inorganic compounds)	0.01	0.002 (15 minute C)
Mercury compounds [except (organo) alkyls] (as Hg)	0.1	0.05 (as vapor)
Antimony	0.5	0.5
Selenium	0.2	0.2
Beryllium (Beryllium and beryllium compounds)	0.002	0.0005
Cobalt (metal dust and fumes)	0.1	0.05
Copper (dusts and mists as copper)	1.0	1.0
Silver (metal dust and soluble compounds, as Ag)	0.01	0.01
Nitric Acid	5	5

2.4 Routes of Exposure

Exposure could occur via inhalation, dermal absorption, or ingestion.

Inhalation sources include windblown dusts during sampling activities. Personnel must take extra care to ensure airborne dust is not generated while sampling and excavating soil areas, and disposing contaminated soils. In order to control inhalation of these metal-contaminated dusts, it will be necessary to control dust levels. Dust control will be most important in areas where metal concentrations are the highest. Measures to reduce exposure to dust include careful sample handling, strict enforcement of practices such as prohibiting personnel from shaking out dusty clothing or using compressed air to blow off dust, and using water to wet the excavation area.

Ingestion of contaminated soil could occur not only from inhaling dust, but also from hand-to-mouth activities. To reduce the possibility of exposure, personnel must wash their hands and face prior to eating, drinking, using tobacco products, or applying cosmetics.

Dermal absorption is not a major route of exposure for the majority of the metal contaminants, but can be a route of exposure for mercury. To reduce the possibility of exposure, personnel should wear personal protective equipment (PPE) such as latex or polyethylene gloves, which limit skin contact with soil and dust.

2.5 Health Effects

Lead (Pb) has been deemed the primary metal of concern as far as regulating exposure during remedial activities. Exposure limits for workers to lead is regulated by OSHA in 29 CFR 1910.1025.

Lead that is inhaled or ingested enters the blood stream, circulates throughout the body, and is stored in various organs and body tissues, primarily in bone marrow. Although some lead is removed via excretion, lead is a cumulative contaminant in the body. Long-term exposure to excessive lead levels can result in damage to blood forming, nerve, urinary, and reproductive systems. Adverse health effects of lead are seen at lower exposure levels in children compared to adults.

Symptoms of overexposure to lead may include loss of appetite, metallic taste in the mouth, anxiety, constipation, irritability, muscle and joint pain or soreness, hyperactivity, and abdominal pain. Severe (acute) over-exposure can damage the central nervous system with symptoms of vomiting, stupor, poor memory, tremor, seizures, and muscular weakness progressing to paralysis of hands and feet. Kidney damage may occur with few symptoms until damage is severe. Reproductive impairment can affect both men and women, with decreased sex drive, impotence, and sterility for men, and decreased fertility and abnormal menstrual cycles for women. Miscarriage, stillbirth, or birth defects may result. Workers who are actively seeking to have a child or who are pregnant should contact qualified medical personnel to arrange for a job evaluation and medical follow-up. Effects in the blood-forming system may include anemia, which is characterized by weakness, pallor, and fatigue. In general, the symptoms described above begin to occur when blood lead levels exceed 30 μg/100 g.

Mercury (Hg) may be a metal of concern during remediation activities. Inhalation of mercury vapors is the most common form of occupational exposure; however, mercury concentrations in outdoor air typically are not a major concern. High levels of metallic, inorganic, or organic mercury can damage the brain, kidneys, or gastrointestinal system and can cause allergic reactions. Effects on the brain may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Acute exposure to high levels of metallic mercury vapors may cause lung damage, nausea, vomiting, diarrhea, increased blood pressure or heart rate, skin rashes, and eye irritation. There is not sufficient evidence to classify mercury as a human carcinogen. Chronic exposure may have an effect on female fertility.

Arsenic (As) also may be a chemical of concern during remediation activities. The most common hazards of occupational exposure to arsenic compounds are irritation of the skin, eyes, mouth, throat and lungs. Chronic poisoning includes cancer of the skin and lungs. Acute poisoning may result in death. Acute poisoning by arsenic compounds other than arsine rarely occurs in industry but has been reported to have occurred as a result of inhalation and skin absorption as well as from ingestion. Recent studies have shown that arsenic and its compounds can cause cancer in humans. Exposure to inorganic arsenic compounds in drugs and the occupational environment is causally associated with the development of skin cancer. Exposure to arsenic compounds has also been associated with increases in the incidence of various other types of cancers, particularly cancer of the lung among copper smelter and pesticide workers.

Section 3.0 Physical Hazards

3.1 Heat

Signs and symptoms of Heat Stress will be monitored by all project personnel. It is imperative that crew members maintain an adequate fluid intake throughout the day. Therefore, liquids will be available, and breaks will be taken periodically during the work day to help prevent heat-related illness and prevent physical exhaustion. Should any of the following symptoms occur—extreme fatigue, cramps, dizziness, headache, nausea, profuse sweating, and pale clammy skin—the affected person is to immediately leave the work area, rest, cool off, and drink plenty of cool water. If the symptoms do not subside after a reasonable rest period, the affected person shall notify their supervisor and the Health and Safety Officer (HSO) and seek medical assistance. The HSO will be alert to signs of heat stress in site personnel and increase the frequency of breaks and fluid consumption as necessary. Following is a description of how to avoid, recognize, and treat heat-related illness:

3.1.1 Heat Stroke

Heat Stroke occurs when the body's system of temperature regulation fails and body temperature rises to critical levels. This condition is caused by a combination of highly variable factors, and its occurrence is difficult to predict. Heat stroke is a medical emergency. The primary signs and symptoms of heat stroke are confusion, irrational behavior, loss of consciousness, convulsions, a lack of sweating (usually), hot, dry skin, and an abnormally high body temperature (e.g., a rectal temperature of 41°C [105.8°F]).

If body temperature is too high, it causes death. The elevated metabolic temperatures caused by a combination of workload and environmental heat load, both of which contribute to heat stroke, are also highly variable and difficult to predict.

If a worker shows signs of possible heat stroke, professional medical treatment should be obtained immediately. The worker should be placed in a shady area and the outer clothing should be removed. The worker's skin should be wetted and air movement around the worker should be increased to improve evaporative cooling until professional methods of cooling are initiated and the seriousness of the condition can be assessed. Fluids should be replaced as soon as possible. The medical outcome of an episode of heat stroke depends on the victim's physical fitness and the timing and effectiveness of first aid treatment.

Regardless of the worker's protest, no employee suspected of being ill from heat stroke should be sent home or left unattended unless a physician has specifically approved such an order.

3.1.2 Heat Exhaustion

The signs and symptoms of heat exhaustion are headache, nausea, vertigo, weakness, thirst, and giddiness. Fortunately, this condition responds readily to prompt treatment. Heat exhaustion should not be dismissed lightly, however, for several reasons. One is that the fainting associated with heat exhaustion can be dangerous because the victim may be operating machinery or controlling an operation that should not be left unattended; moreover, the victim may be injured when he or she faints. Also, the signs and symptoms seen in heat exhaustion are similar to those of heat stroke, which is a medical emergency.

Workers suffering from heat exhaustion should be removed from the hot environment and given fluid replacement. They should also be encouraged to get adequate rest.

3.1.3 Heat Cramps

Heat cramps are usually caused by performing hard physical labor in a hot environment. These cramps have been attributed to an electrolyte imbalance caused by sweating. It is important to understand that cramps can be caused by lack of water replenishment. Because sweat is a hypotonic solution (±0.3% NaC1), excess salt can build up in the body if the water lost through sweating is not replaced. Thirst cannot be relied on as a guide to the need for water; instead, water must be taken every 15 to 20 minutes in hot environments.

Under extreme conditions, such as working for 6 to 8 hours in heavy protective gear, a loss of sodium may occur. Recent studies have shown that drinking commercially available carbohydrate-electrolyte replacement liquids is effective in minimizing physiological disturbances during recovery.

3.1.4 Heat Collapse

In heat collapse, the brain does not receive enough oxygen because blood pools in the extremities. As a result, the exposed individual may lose consciousness. This reaction is similar to that of heat exhaustion and does not affect the body's heat balance. However, the onset of heat collapse is rapid and unpredictable. To prevent heat collapse, the worker should gradually become acclimatized to the hot environment.

3.1.5 Heat Rashes

Heat rashes are the most common problem in hot work environments. Prickly heat is manifested as red papules and usually appears in areas where the clothing is restrictive. As sweating increases, these papules give rise to a prickling sensation. Prickly heat occurs in skin that is persistently wetted by unevaporated sweat, and heat rash papules may become infected if they are not treated. In most cases, heat rashes will disappear when the affected individual returns to a cool environment.

3.1.6 Heat Fatigue

A factor that predisposes an individual to heat fatigue is lack of acclimatization. The use of a program of acclimatization and training for work in hot environments is advisable. The signs and symptoms of heat fatigue include impaired performance of skilled sensorimotor, mental, or vigilance jobs. There is no treatment for heat fatigue except to remove the heat stress before a more serious heat-related condition develops.

3.1.7 Control and Treatment of Heat Disorders

Ventilation, air cooling, fans, shielding, and insulation are the five major types of engineering controls used to reduce heat stress in hot work environment. Heat reduction can also be achieved by using power assists and tools that reduce the physical demands placed on a worker.

However, for this approach to be successful, the metabolic effort required for the worker to use or operate these devices must be less than the effort required without them. Another method is to reduce the effort necessary to operate power assists. The worker should be allowed to take frequent rest breaks in cooler environment.

3.1.7.1 Acclimatization

The human body can adapt to heat exposure to some extent. This physiological adaptation is called acclimatization. After a period of acclimatization, the same activity will produce fewer cardiovascular demands. The worker will sweat more efficiently (causing better evaporative cooling) and thus will more easily be able to maintain normal body temperatures.

A properly designed and applied acclimatization program decreases the risk of heat-related illnesses. Such a program basically involves exposing employees of work in a hot environment for progressively longer periods. NIOSH (1986) says that, for workers who have had previous experience in jobs where heat levels are high enough to produce heat stress, the regimen should be 50% exposure on day one, 60% on day two, 80% on day three, and 100% on day four. For new workers who will be similarly exposed, the regimen should be 20% on day one, with a 20% increase in exposure each additional day.

3.1.7.2 Fluid Replacement

Cool (50°-60°F) water or any cool liquid (except alcoholic beverages) should be made available to workers to encourage them to drink small amounts frequently (e.g., one cup every 20 minutes). Ample supplies of liquids should be placed close to the work area. Although some commercial replacement drinks contain salt, this is not necessary for acclimatized individuals because most people add enough salt to their diets.

3.2 Biological Hazards

There are a range of biological hazards endemic to Nigeria. All personnel are advised to check with current Centers for Disease Control (CDC) guidance and receive recommended immunizations (http://wwwnc.cdc.gov/travel/destinations/nigeria.aspx). This section provides a brief summary of the hazards that may be encountered and is not meant to supplement advice given to you by a doctor. It is highly recommended that personnel discuss these potential hazards with their physician prior to departure.

3.2.1 Malaria

Malaria is a serious disease and may be a deadly illness. Humans get malaria from the bite of a mosquito infected with the parasite. Prevention measures include taking an effective prescription antimalarial drug recommended for use in Nigeria and by protecting yourself against mosquito bites. It is mandatory for all international staff to take malaria prophylaxis. Sleeping under a bed net and using mosquito repellent when outside in the evenings will further prevent malaria.

Malaria symptoms may include fever, chills, sweats, headache, body aches, nausea and vomiting, and fatigue. Malaria symptoms will occur at least 7 to 9 days after being bitten by an infected mosquito. The CDC explains,

> "Malaria may cause anemia and jaundice. Malaria infections with Plasmodium falciparum, if not promptly treated, may cause kidney failure, coma, and death. Despite using the protective measures outlined above, travelers may still develop malaria up to a year after returning from a malarious area. You should see a doctor immediately if you develop a fever anytime during the year following your return and tell the physician of your travel" (CDC 2010).

3.2.2 Cholera, Food/Waterborne Illness, and Other Biohazards

Cholera is a serious, acute disease caused by the bacterium Vibrio cholerae. Humans can be infected by drinking or eating food or water that has been contaminated with cholera organisms. Initial symptoms may include vomiting, headache, and pain, with little or no fever and may progress into profuse watery diarrhea with a “rice water” appearance. Fluid loss is the main concern, as it may exceed 5 to 10 liters a day. If left untreated, death can result from dehydration, hypovolemia, and shock.

Prevention is key for cholera and other food or waterbourne illnesses. To prevent food/waterbourne illnesses, only bottled or filtered drinking water should be consumed. When eating, you should follow the guidelines: “Cook it, Peel it, or Leave it.” If a food is not cooked thoroughly, peeled, or pasteurized, you should avoid eating it. Food from the local villages should be avoided due to food/waterbourne illness as well as high levels of lead contamination. Wash your hands often with soap and water, especially before eating. If soap and water are not available, use an alcohol-based hand gel (with at least 60% alcohol).

The World Health Organization (WHO) specifically recommends the following for preventing Cholera.

- Drink only water that has been boiled or disinfected with chlorine, iodine or other suitable products. Products for disinfecting water are generally available in pharmacies, hospitals and dispensaries. Beverages such as hot tea or coffee, wine, beer, carbonated water or soft drinks, and bottled or packaged fruit juices are also usually safe to drink
- Avoid ice, unless you are sure that it is made from safe water.
- Eat food that has been thoroughly cooked and is still hot when served. Cooked food that has been held at room temperature for several hours and served without being reheated can be an important source of infection.
- Avoid raw seafood and other raw foods, except fruits and vegetables that you have peeled or shelled yourself. Remember: Cook it, peel it, or leave it.
- Boil unpasteurized milk before drinking it.
- Ice cream from unreliable sources is frequently contaminated and can cause illness. If in doubt, avoid it.
- Be sure that meals bought from street vendors are thoroughly cooked in your presence and do not contain any uncooked foods. (WHO, 2010).

For more information on exposures from biohazards, you can refer to:

http://www.elcosh.org/en/document/783/d000734/exposure-to-biohazards.html

http://www.hse.gov.uk/pubns/indg198.pdf

3.2.3 Other Diseases, Insects, and Parasites

The CDC recommends travelers are immunized against Polio, Typhoid, Hepatitus A and B, Meningococcal disease (meningitis), and Yellow Fever. Dengue, filariasis, leidhmaniasis, and onchocerciasis (river blindness), and African trypanosomiasis (African sleeping sickness) are other diseases carried by insects that occur in West Africa. Protecting yourself from insect bites will help to prevent these diseases. To prevent Schistosomiasis, a parasitic infection, which can be contracted in fresh water, you should not swim in fresh water. This region also has high incidence rates of tuberculosis and high HIV prevalence rates.

Because highly pathogenic avian influenza (H5N1) has been found in poultry populations in several countries in Africa, avoid all direct contact with birds, including domestic poultry (such as chickens and ducks).

Additional insect hazards include bed bugs, scabies, poisonous spiders, scorpions, wasp/bee stings, and mosquitoes (discussed previously). Protective clothing (long sleeved-shirts and pants) should be worn, and skin/clothing inspected periodically for evidence of bites. Insect repellent should be used, if needed, and any allergies should be reported to the project manager and site safety officer prior to starting work. Allergy medications should be carried at all times.

For the prevention of other communicable diseases, personnel will avoid using bathroom areas in local compounds.

3.2.4 Animals

Direct contact with animals can spread diseases like rabies or cause serious injury or illness. It is important to prevent animal bites and scratches. Dogs and/or angry livestock may be encountered in conducting sampling/excavation activities. Be sure you are up to date with tetanus and rabies vaccinations. Do not touch or feed any animals, including dogs. Even animals that look like healthy pets can have rabies or other diseases. If you are bitten or scratched, wash the wound well with soap and water and go to a doctor right away. After your trip, be sure to tell your doctor or state health department if you were bitten or scratched during travel (CDC, 2010). In addition, avoid confined spaces where rodents may be or have been living.

3.3 Roads and Vehicles

Nigerian roads are unsafe and insecure: many vehicles and roads are in bad condition, and when roads are in good condition, people drive too fast. The following are some steps you can take to prevent unsafe situations (adopted from MSF guidelines).

- Only travel in vehicles that have been approved by TerraGraphics and MSF.
- Any passenger can ask the driver to slow down, if he/she feels unsafe. Similarly, passengers must not ask to go faster than the driver feels is safe.
- Seatbelts must always be worn when available.
- Do not travel after dark, unless absolutely necessary.
- Travel with at least one other person.
- International personnel are not permitted to drive a vehicle anywhere in Nigeria, unless approved by the project manager. An exception to the rule is that you are allowed to drive in an emergency situation when the risk of not driving yourself is bigger than the risk of driving (for example when your driver falls ill in a remote area and driving yourself is the only way to reach a town before dark).
- When crossing a street or working near a road, be extremely aware of your surroundings.

3.4 Radiation

Portable X-ray Flourescence Analyzers (XRFs) will be used while sampling. These machines produce x-rays. They will only be used after personnel have been properly trained.

Exposure to radiation from XRFs can be prevented by the following guidelines:

- Minimize your time of exposure (perform the sampling as quickly and as efficiently as possible without increasing the probability of exposures).
- If available, keep the safety lock engaged whenever the XRF analyzer is not in use.
- Maximize the distance from the source: Never point this instrument at anyone (including yourself), be sure no person is directly in the line of the window of the XRF, and do not put your fingers, hands, feet, or other body parts in front of the XRF while it is in use.

Radiation sickness can occur if a high does of radiation penetrates most of the body, usually within a short time frame. Ionizing radiation affects people by depositing energy in body tissue, which can cause cell damage or cell death. In some cases there may be no effect. In other cases, the cell may survive but become abnormal, either temporarily or permanently, or an abnormal cell may become malignant.

Chronic exposure is continuous or intermittent exposure to low levels of radiation over a long period of time. Chronic exposure may produce only effects that can be observed some time following initial exposure. These may include genetic effects and other effects such as cancer, precancerous lesions, benign tumors, cataracts, skin changes, and congenital defects.

3.5 Noise

Certain operations may create noise levels that exceed the applicable limits. Operations expected to be in excess of 85 decibels adjusted (dBA) steady state or 140 dBA impulse will require either hearing protection and/or isolation of unprotected workers from the noise source. As a rule of thumb, doubling of distance will reduce noise exposure by 6 decibels (dBs). Hearing protection will be provided for oversight personnel and will be required when noise levels warrant their use.

3.6 Heavy Equipment

Heavy equipment will be used during remediation. The following guidance should be used when working near heavy equipment.

- Provide heavy-equipment operator with an observer when needed to assure safety or to assist with work.
- When changing operators, ensure that person in charge discusses plan of work, existing hazards, hand signals, etc., with new operator and crew.
- Don’t stand directly in front of or in back of a self-propelled machine while it is being started.
- Don’t go under or around equipment without notifying operator. Look out for hazards.
- Never get on or off moving equipment.

- Rope off area of swing to provide ample clearance for a person between any solid material and tail swing of a dragline, shovel, or crane.
- Stop all engines before refueling. When filling gasoline tank, keep funnel or container in contact with tank to prevent static spark. Never fill tank over a hot engine. Provide grounding as appropriate.
- Always leave machines with moveable parts that are lowered by gravity, such as shovels, buckets, and skip loaders, resting on the ground.
- Don't operate internal combustion engines indoors, except with proper ventilation.
- Have a qualified person inspect machinery or equipment, including that under contract, when it's received or repaired. Be sure it's in safe operating condition before turning it over to the operator.
- Have operators continually inspect their machines for safe operating conditions. Promptly notify supervisors when repairs are needed. Shut down defective machinery until repairs are made.
- All gears, sprockets, shafts, augers, drivebelts or chains, pulleys, drums, gears, fans, or other hazardous moving parts must have guards. Replace guards after any repairs are completed.
- Install operating platforms surfaced with nonskid materials on footwalks, ladders, steps, handholds, guardrails, and toeboards before operating machine.
- Provide suitable protection for the operator against falling objects, swinging loads, and similar hazards.
- Use safety glass in shields, cabs, or enclosures on machines.
- Post signalman at dangerous or congested points near crews, blind areas, camp, etc.
- Check route of travel for hazards such as insufficient overhead and side clearance, bridges, high-tension lines, etc. (BLM, 2010).

3.7 Other Physical Hazards

There is a potential for slipping, tripping, and falling while working. All personnel working on the project will be aware of walking surface conditions and watch for slipping, tripping, and falling hazards. All project personnel will wear appropriate PPE identified below.

Bending, kneeling, and lifting will be required during both sampling and remediation activities. Bending at the waist should be avoided. Proper lifting techniques should be used. Knee pads will be provided if needed.

Meteorological conditions will be watched closely, especially in the spring, summer and fall when severe thunderstorms are likely to occur. Thunderstorms often occur late in the afternoon on hot spring days, but can occur at any time of the day in any season of the year. All outdoor work shall cease immediately during a thunderstorm or severe thunderstorm warning in the local area.

Section 4.0 Personal Security

Nigeria is not a country in conflict but there are sometimes some outbreaks of violence. They are mainly linked to political issues and religious conflicts. A much greater concern of day-to-day safety is road safety, in addition to random violence and banditry. Personnel's attitude, actions, and preparedness will ultimately impact their security.

Each individual is responsible for his/her own personal safety and must remain familiar with the security plans. Each individual must follow the regulations of TerraGraphics, MSF, and local laws and take active part in risk management. International staff should bring with him/her the following items on any movement outside the project bases: passport (or copy including visa page), security money (in USD and Naira), mission order (i.e., copy of letter of invitation), ID, charged mobile phone (with call credit) and updated contact list for the mission and the project. Satellite phones are available for areas without cell coverage.

When travelling in vehicles, be equipped with recovery equipment, water and emergency food stocks, a fully-stocked first aid kit, a map of Nigeria, and other relevant project area maps. Avoid splitting the team, during any security incident, such as during a shooting, at a tense roadblock, during armed robbery or attempted kidnapping. In MSF's terms, unless people are 'putting a gun to a team member's head', the team should collectively and diplomatically insist that they do not wish to separate - if one goes, then all go. This is especially important for splitting international - and national staff members, male and female team members. If splitting cannot be avoided, the next best option is that no one goes alone; with preferably no groups existing of only females.

4.1 Personal behavior and communication

4.1.1 Personal behavior

International personnel will be working in a culture that is not always familiar. People might have different ways and habits than what personnel are used to. These general guidelines, adopted from MSF guidance, should be followed by international personnel.

- Dress appropriately, especially when travelling in Muslim areas.
- Show respect for the opinions, knowledge, living style, religion, beliefs, and attitudes of target and host populations and co-workers
- Maintain a low profile: Do not ostentatiously display your wealth, foreign status, or personal opinions about religious, social, cultural and political issues.
- Be tactful and diplomatic: Avoid getting into disputes with local people and displaying anger or arrogance. Avoid arguments about sensitive cultural or political issues with people you do not know well. Refrain from making disapproving or even derogatory comments about local customs and habits. Always be respectful while making yourself respectable. In project matters make time to listen to people's concerns, priorities, and complaints. Don't make promises you can't keep or leave disputes unresolved.
- Maintain constant situational awareness: At all times you should remain aware of the broader context you are working in and how you might be perceived or portrayed. Keep your eyes and ears open and listen to people's opinions and be aware of local perceptions

through listening to/talking with national colleagues and local people. In the actual location maintain "terrain awareness": know where you are, scan the environment for potential threats and for where you might find help or cover or in what direction evasive action might be taken.

- Remain security conscious: Understand MSF security guidelines, rules and rationale and accept that in violent environments it is insecurity and danger rather than organizational measures that generate the constraints on personal freedom. Understand that your risk-taking behavior can put colleagues at risk and affect the image or actions of your organization. Remain aware that no civilian in need is helped by you getting injured or killed. Feel responsible for security and act when security measures are neglected on the road, around the office, or during and after working hours.
- Maintain contact and communications: Always let someone know when and where you are going and when you expect to be back. This is a compromise on your privacy, for the sake of your security. Do not just 'disappear' without anybody knowing where you are. Don't go out without means of communication. Us the sign in/sign out board!
- Be prepared to face a threat: In practical terms this means knowing the basic principles and/or procedures to follow in the case of specific threats/incidents. It also includes mental preparedness to maintain self-control to help you to respond adequately and effectively to a situation of potential danger, or cope better with what you are to undergo.
- Friendships with Nigerians should be same-sex friendships only, as opposite-sex friendships are easily seen as sexual relationships (homosexual relationships with Nigerians are not allowed). Do not do or say anything to create the perception/suggestion of having a sexual relationship with a Nigerian.

4.1.2 Documentation and Communication

International staff's video material and images taken in operational areas can be a hot issue. If you want to take pictures/videos in potentially sensitive contexts, please discuss this first with your project manager. The following MSF guidelines summarize what international personnel should be aware of:

- Under NO circumstances, take pictures of armed forces, objects or any armed personnel uniformed or in plainclothes. Don't try to take picture of people praying! The same rule applies to security-relevant places and buildings like airports, major bridges, most governmental buildings (e.g., Ministry of Defense), etc. Always ask before taking someone's picture. Do not post any photos or movies including people that have not given explicit permission to having their picture published on any part of the internet; this includes colleagues, patients, caretakers, bystanders, or any other member of the general public. This means you need to seek permission to post a photo or movie from every person in it on every occasion of posting (making explicit the world-wide viewing which is possible).
- Personal web blogs, postings, etc. are often read by a large audience; in sensitive contexts they could be potentially risky. Be careful also on what you write in your emails; be aware that often the authorities can read them for spying specially in a context where MSF is seen to be a disturbance by authorities.

- Speak about personal experiences in the past only; do not talk about plans that TerraGraphics or MSF may have.
- Do not speak about communication equipment or procedures other than those related to mobile phones.
- In principle avoid reference to any person (patient, caretaker, government official, MSF colleague, NGO/UN/Other employee) who may be identified based on the posted information; make sure remarks about any of these persons are in-line with what you would tell the person face-to-face as well.
- It may be advisable to limit contact to emails only directed specifically at one or more among the people you want to communicate with. Note, however, that also in such personal communications the basic rules above (especially those regarding security; i.e., with respect to movements, names and numbers of MSF staff and communication equipment or procedures) need to be adhered to.

4.2 Security events

There are many potential security threats that may unpredictably occur in Nigeria, including angry crowds/riots, banditry, car accidents, car hijacking, rape, abduction, and armed robbery. MSF has analyzed the likelihood of these risks and have guidelines that specify what to do if a security event such as this occurs (MSF, 2010). Our team receives the MSF security event communications.

Section 5.0 Work Practices

Work activities generally involve disturbance of potentially contaminated soil and conducting property measurement activities. Interaction with property owners is also conducted. In general, lifting objects more than 40 pounds is anticipated, and proper lifting procedures should be followed. If possible, the load to be lifted should be lightened. Where lifting of heavy objects or bending is required, proper techniques include bending at the knees and keeping backs straight, or obtaining assistance from other crew members.

Team members need to limit the creation and spread of dust. Practices such as shaking out dusty clothing or using compressed air to blow off dust will be strictly prohibited, and dust control measures such as wetting work surfaces will be utilized. The following work practices will be observed:

- Work will occur during daylight hours only.
- No eating, drinking, chewing, or smoking will be allowed while conducting reconnaissance activities.
- The buddy system will be used at all times.
- Walking and working surfaces will be monitored for slip, trip, and fall hazards.
- Equipment used during the program will be carefully inspected at the beginning of each day prior to work start up. Failure of any of the equipment must be reported immediately to the project manager or the field operations manager.

All employees are responsible for performing the tasks assigned to them in accordance with the HSP and all applicable occupational safety and health rules and regulations. All employees are responsible for notifying their immediate supervisor or HSO of any unsafe practice or condition.

5.1 Personal Protective Equipment

For personal protection, crew members will wear latex/nitrile gloves while collecting and handling samples, and excavating and disposing contaminated soils. Nitrile gloves should be worn by personnel with an allergic reaction to latex. Coveralls will be worn during excavation and disposal of contaminated soils. Dust masks will be worn during excavation activities, while respirators will be worn during disposal activities. Eye protection and ear plugs will be required when working near heavy equipment. Crew members will be required to wear shoes during soil sampling, excavation, and disposal procedures.

5.2 Decontamination and Disposal Procedures

Before leaving the site, personnel will:

- Remove latex/nitrile gloves and discard in a garbage bag.
- Thoroughly wash hands and face with soap and water before eating, drinking, or smoking. If water is not available use pre-moistened towelettes to wash face and hands.
- Remember: Do not track contaminated soils and dust off-site.

At the end of the work day, personnel will:

- Remove latex/nitrile gloves and discard in a garbage bag.
- Thoroughly wash hands and face with soap and water before eating, drinking, or smoking. If water is not available use pre-moistened towelettes to wash face and hands.
- Leave coveralls and field boots in the designated area. Coveralls will be washed on a regular basis. Disposable coveralls can be disposed of with the rest of the waste collected on site.
- Wash all exposed skin surfaces to include face, arms and hands before leaving the site.
- Take a complete shower and shampoo hair at home at the end of the work day.

Sampling equipment will consist of a spoon for collecting the samples, which will be decontaminated after collecting a sample. If a sample is collected, the sample bags will be sealed shut, marked with indelible marker, and any excess dirt will be wiped from the outside of the sample bags before they are stored. Sample bags will be transported in sealed plastic bags placed in stable containers that can be securely closed.

The interior of any vehicles used as part of the project will be cleaned/wiped down at least once a week to remove any excess dust.

Documentation of decontamination must be entered in the field log book, which will become part of the permanent project file.

Collect trash in plastic garbage sacks and dispose of it at specified sites.

5.3 Emergency Procedures

Confirm and post emergency phone numbers, location of nearest phone and route to the hospital. Be sure these emergency numbers and hospital map are located in the vehicle. At least one vehicle must be available for emergency use.

Section 6.0 Incident Reporting

If an injury occurs, take the following steps:

- If the emergency requires urgent medical attention, contact a doctor with MSF immediately. Also notify project managers (Casey and Simba) and they will notify appropriate personnel in Zamfara and the US.
- Initiate first aid and get medical attention for the injured person immediately.
- Depending on the type and severity of the injury, call for medical attention using a hand-held radio, cell phone or pay phone.
- Report any incidents to the Project Manager and forward it to the healthy and Safety Officer (HSO). The HSO will forward to the Moscow and New York Offices.

The following list provides names and telephone numbers for emergency contact personnel. In the event of an emergency, the Project Manager will notify the appropriate emergency organization and/or the appropriate local, state, and federal agencies:

Emergency Contacts

Contact Telephone	
Ian vonLindern	US: +1 208 596 8577 Nig: +234 (0)816 049 6658
Margrit von Braun	US: +1 509 339 5583 Nig: +234 (0)816 961 3824
Casey Bartrem – TerraGraphics Simba Tirima - TerraGraphics John Keith - Blacksmith Meredith Block - Blacksmith US Embassy, Nigeria	US: +1 517 899 5932 Nig: +234 (0)816 049 6659 Nig: +234 (0)806 637 2786 Nig: +234 (0)816 961 3763 +1 917 273 7444 +234 (9)461-4176 +234 (9) 461-4000

MSF Emergency Contacts

Nigeria: +234		Position-related phone numbers		Mail and general phone numbers
	Project Coordinator	Ellen	7031633593	msfh-zamfara-pc@field.amsterdam.msf.org
	Medical Team Leader	Shafie	7038311995	msfh-zamfara-med@field.amsterdam.msf.org
	Resource Team Leader	William	8130016793	Always use both Anka and Bukkuyum mail addresses (William is usually in Bukkuyum, Jennifer, Jane and John are more in Anka, Dismus spends his time 50/50)
	Labtech	Dismus	8063953593	
	Health Promoter	Jennifer	8074680025	
	Epidemiologist	Jane	8130016745	
	Remediation log	John	8063947422	
Anka location				
	Log Anka	Mairi	8165779392	msfh-anka@field.amsterdam.msf.org
	MD Anka	Nathalie	7063529955	Back up phone GLO: 07051204620
Anka	Hospital Nurse Anka	Marcia	8162783395	Back up phone BGAN: not operational
	Outreach Nurse Anka	Moniek	8130016790	Thuraya 2 +8821655537823
	Outreach Nurse Anka	Mira	7063598761	Thuraya 4 +8821655537160
	Outreach Nurse Anka			
Bukkuyum location				
	Log Bukkuyum	Michel	7038919026	msfh-zamfara@field.amsterdam.msf.org
Bukkuyum	MD Bukkuyum	Ernesto	8072615115	Back up phone GLO: 08071423795
	Hospital Nurse Bukkuyum	Janet	8038504684	Back up phone BGAN: +870772500597
	Outreach Nurse Bukkuyum	Freda	8130016799	Thuraya 1 +8821655537931
				Thuraya 3 +8821655537174

For additional contacts see the briefing materials in the Zamfara Emergency Lead Response Volunteer Handbook.

Section 7.0 References

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