NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

THE U.S. ARMY CHEMICAL CORPS AND A FUTURE WITHIN AFRICOM

by

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March 2009

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REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 2009	Master's Thesis

4. TITLE AND SUBTITLE The U.S. Army Chemical Corps and a Future Within AFRICOM	5. FUNDING NUMBERS
6. AUTHOR(S) Kirsten S. Graf	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited	

13. ABSTRACT (maximum 200 words)

The United States Africa Command (USAFRICOM) was established in October 2007 to encompass all U.S. operations on the African continent under one unified command. Several African nations have a history of chemical, biological, radiological, and nuclear operations, while most countries have a history of use as dumping grounds for hazardous materials and toxic industrial materials. Africa has also suffered extreme environmental degradation due to these and other causes. The US Army Chemical Corps has increased its capabilities to include not only chemical, biological, radiological, and nuclear operations, but all hazardous material, toxic industrial material, and environmental operations for the US Army. The Chemical Corps has also increased capabilities for disaster and crisis response and management since September 11th, 2001, and utilized some of those capabilities during Hurricane Katrina.

One of AFRICOM's primary goals is to build partner capacity so that African governments can provide security and respond in times of need. The Chemical Corps can assist with the realization of these goals.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Chemical Corps, CBRNE, Toxic Industrial Material (TIM), Hazardous Material (HAZMAT), AFRICOM, Environment	93
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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THE U.S. ARMY CHEMICAL CORPS AND A FUTURE WITHIN AFRICOM

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MASTER OF SCIENCE IN DEFENSE ANALYSIS

from the

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ACKNOWLEDGMENTS

I would first like to thank my advisors, Professors Anna Simons and Jessica Piombo, for all of their guidance, corrections, invaluable knowledge throughout the entire thesis process, and patient understanding as I wrote draft after draft of this thesis. I could certainly not have done this without them. Secondly, I would like to thank Emily Brown, my dear friend, daughter's godmother, and personal librarian. Her research skills and resources were great assistance in getting my thesis started. Librarians provide incomparable research assistance, and so I would also like to thank NPS Librarian Greta Marlatt for all of the assistance she provided to me. I would like to thank all of my professors for the way they guided me in pursuit of my academic successes, particularly Professor George Lober, who ensured my classmates and I remembered HOW to write after several years in service. I would like to thank my fellow Chemical Officers for writing about their experiences and publishing them so I could use them in this thesis. Particular thanks to LTC Pete Lofy, who always had time to answer my questions. Thank you also to everyone who helped me get to this point in my career.

Finally, I would like to acknowledge the support and love of my family. While my parents, sisters, and in-laws may not have always understood what I was talking about, they were and are always supportive and encouraging. Last, but definitely not least, I would like to thank my wonderful husband, Rudi, for taking care of Adelaide and our home as much as humanly possible so I could get work done. As for Adelaide our beautiful baby girl, she has provided so much

love, distraction, and playtime that I thought I might never finish my thesis. I would like to thank Adelaide and Rudi for keeping me grounded in what really matters.

I. INTRODUCTION

A. THE CHEMICAL CORPS AND AFRICOM

United States Africa Command (AFRICOM) represents a new Geographic Combatant Command (GCC), designed to focus on Africa and take over the missions of the European Command (EUCOM), Pacific Command (PACOM), and Central Command (CENTCOM) on the continent. AFRICOM has been created quickly in the last two years to bring all U.S. operations on the continent together under one unified command. Several African countries have a history of chemical, biological, radiological, and nuclear (CBRN) access, research, development, and/or use. Africa also has potential for non-traditional operations by the Chemical Corps including training for cleanup and storage of hazardous materials (HAZMAT) and toxic industrial materials (TIM), and natural disaster response. This thesis aims to provide guidance for the Chemical Corps with regard to activities and trends to watch for, based on historical events in Africa and the Corps' current and future abilities.

B. U.S. CHEMICAL CORPS HISTORY

The Chemical Corps, originally named the Chemical Warfare Service (CWS), was established by the War Department in 1918 in response to the use of chlorine gas in the trenches during World War I. Congress made the CWS a permanent branch of the Army in 1920 on the premise that chemical warfare was a likely threat in any future conflict.

The CWS was intended to manage chemical warfare programs for the U.S. military, both offensive and defensive. In the years between World War I and World War II, the CWS developed both a strong offensive capability and an effective defensive posture. During that time, the CWS expanded its capabilities to include the 4.2-inch chemical mortar and smoke generators, capable of delivering smoke and high explosive munitions in support of combat missions. The CWS also introduced a variety of flame and incendiary weapons systems during that time. In 1942, the CWS added biological developments to its list of responsibilities and in 1946 was redesignated the Chemical Corps. In 1949, the Chemical Corps added research and development responsibilities for radiological warfare.

During the Korean War, the Chemical Corps conducted the longest continuous smoke screen mission — protecting troop movement in Artillery Valley for 14 months. The 4.2-inch Chemical Mortar battalions also conducted extensive combat operations. The mortar capability was transferred to the infantry in 1953.

The Vietnam War saw the Chemical Corps develop and introduce aerial “people sniffers” to find the enemy. It also introduced thickened fuel flame devices (napalm) to protect firebases, herbicides to clear fields of fire, and tear gas to keep both the enemy at bay and crowds under control. Following the war, there was some discussion about deactivating the Chemical Corps, but the ensuing Cold War kept the Corps active.

In 1972, the United States renounced the use of biological weapons and, in 1997, the use of chemical

weapons. Despite the U.S. promise to not use these weapons offensively, a defensive need kept the Chemical Corps an active branch of the Army.

In 1991, Operations Desert Shield and Desert Storm found the Corps protecting the forces against a chemically and biologically well-armed adversary. Beginning with the terrorist attacks on U.S. soil on September 11, 2001, and the October 2001 anthrax attacks, the Chemical Corps expanded its responsibilities to include protecting the homeland with the introduction of Civil Support Teams, conducting sensitive site exploitation, and maintaining an ever-evolving protective stance. Chemical Soldiers and units have been active participants in every stage and phase of Operations Iraqi Freedom and Enduring Freedom (Afghanistan). The variety of missions they have conducted range from traditional missions to hazardous material and toxic industrial material clean-up and storage, and even duties outside of their scope of operations, such as convoy escort and detainee operations.[1]

C. CAPABILITIES OF THE CHEMICAL CORPS

The Chemical Corps has a long history of evolving missions. In what follows these will be separated and discussed as "traditional" and "non-traditional" missions.

Capabilities include chemical, biological, and radiological (CBR) reconnaissance and detection, decontamination, defensive smoke and flame operations, Civil

[1] U.S. Army Chemical, Biological, Radiological, Nuclear School, "U.S. Army Chemical Corps History," *History,* http://www.wood.army.mil/cbrns/history.html (accessed February 28, 2009).

Support, sensitive site exploitation, technical escort capabilities, clean-up and storage of hazardous materials (HAZMAT) and toxic industrial materials (TIM), and environmental protection.

1. Traditional CBRN Operations

The traditional duties of the Chemical Corps include counter-proliferation of chemical, biological, radiological, and nuclear weapons. These operations include four core capabilities, most of which are Chemical Corps - specific, although they are designed to be incorporated into all branches of the Department of Defense (DoD) and across the U.S. Government's (USG) efforts to combat proliferation. The four capabilities are counterforce, active defense, passive defense, and consequence management.[2]

a. Counterforce

Personnel conducting counterforce operations attack adversary CBRN weapons and their associated production, transportation, and storage facilities before they can be used in order to reduce the CBRN threat to friendly operations and interests.[3] Special Forces and other combat arms branches of the military would assist with conducting these types of operations.

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[2] U.S. Army Chemical School (USACMLS), *FM 3-11: Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical Defense Operations* (US Army Training and Doctrine Command, Fort Monroe, VA: 2003), I-3.

[3] Ibid.

b. Active Defense

The branches of service conducting active defense intercept conventional and unconventional CBRN delivery means – whether through air defense or active ground defense. Together, counterforce operations and active defense reduce the burden on passive-defense measures.[4] Air Defense Artillery and the Air Force primarily conduct the air defense operations, while all branches of the Department of Defense conduct active ground defense.

c. Passive Defense

Passive defense protects personnel from the effects of a CBRN attack and allows sustained operations. The elements of passive defense include; contamination avoidance, protection, and decontamination. This comprises the bulk of what the Chemical Corps does and can do in either a military or a civilian scenario.[5]

Contamination Avoidance—Includes measures taken to avoid or minimize CBRN attacks and reduce the effects of CBRN hazards. Contamination avoidance includes contamination detection and identification, CBRN reconnaissance, mitigating contamination, intelligence preparation of the battlefield (mapping potential target areas and primary decontamination locations, etc.), vulnerability assessments, and hazard prediction.[6]

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[4] U.S. Army Chemical School (USACMLS), *FM 3-11: Multiservice Tactics, Techniques, and Procedures,* I-3-4.

[5] Ibid., I-4.

[6] Ibid., II-2-6.

Protection—There are several protective measures: individual protection, reaction to attack, and the use of collective protection. The techniques used for avoidance also provide protection.[7] While the use of collective protection requires equipment which is most likely not available to everyday citizens, there are some measures everyday civilians can utilize. These are discussed in the recommendations section of the Conclusion.

Decontamination (During Hostilities)[8]—CBRN agent contamination should be avoided when possible. When this is not possible, personnel and equipment must be decontaminated to reduce or eliminate the risk to personnel and to make equipment serviceable. Decontamination procedures are designed to neither degrade the performance of personnel or equipment nor harm the environment. There are four levels of decontamination: immediate, operational, thorough, and clearance. These levels of decontamination are graded from what is considered a basic necessity (immediate) to total (clearance) decontamination with each level increasing the requirements needed to conduct the decontamination.[9]

While these are the standard forms of decontamination during hostile operations, decontamination can (and is) also performed during peacetime operations or in response to a CBRN attack outside of combat operations. For instance, in the case of the massive anthrax attack in

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[7] U.S. Army Chemical School (USACMLS), *FM 3-11: Multiservice Tactics, Techniques, and Procedures,* II-7.

[8] Ibid., II-12.

[9] U.S. Army Chemical School (USACMLS), *FM 3-11.5: Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination* (US Army Training and Doctrine Command, Fort Monroe, VA: 2006), I-2.

October 2001 on the Hart Senate Building in Washington, D.C., Captain Lindsey Nagtzaam enumerates four doctrinal decontamination principles:

- Decontaminate as soon as possible
- Decontaminate only what is necessary
- Decontaminate as far forward as possible
- Decontaminate by priority[10]

In 2007, Ardent Sentry was a mass casualty simulation scenario in which a terrorist detonated a nuclear device in Indiana. The scenario involved the Department of Defense, Indiana Department of Homeland Security, and Indianapolis Department of Public Safety, as well as several other governmental organizations and non-governmental organizations. In light of this exercise, these groups realized the need for set communication lines and coordination among the groups in order to properly respond to any such scenario. The groups also discovered differences in decontamination techniques among the organizations and agencies and identified additional gaps in readiness. Some of the area requiring further work were:

- Personnel to be decontaminated
- Multi-site operations
- Integration of decontamination operations with other plans
- Disposition of runoff
- Disposition of personal effects
- Accountability
- Crowd control operations[11]

[10] Lindsay Nagtzaam, "Anthrax Decontamination," *Army Chemical Review,* January 2003.

d. Consequence Management

Consequence management includes measures to provide emergency assistance to civilian authorities when directed by the chain of command. Consequence management measures could be required during any phase of operations, depending on the threat and availability of assets.[12] Emergency assistance could include the eight military mission areas, from the "National Military Strategy to Combat Weapons of Mass Destruction":

- Security cooperation and partner activities
- Threat reduction cooperation
- Interdiction operations
- Offensive operations
- Elimination operations
- Active defense
- Passive defense
- Weapons of mass destruction (WMD) consequence management[13]

The reorganization and redevelopment of the Chemical Corps in the past few years in accordance with the Modular Army concept has enabled the Corps to better conduct consequence management. The CBRNE[14] Company Team is a new structure brought about by the reorganization.

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[11] Michael L. Snyder and Thomas J. Sobieski, "Decontamination Operations in a Mass Casualty Scenario: Observations from Ardent Sentry 2007," *Army Chemical Review,* Summer 2008, 10-15.

[12] U.S. Army Chemical School (USACMLS), *FM 3-11: Multiservice Tactics, Techniques, and Procedures,* I-4.

[13] Pete Lofy, "CBRNE CO TMs in Support of WMD-E Operations," *Army Chemical Review,* Winter 2008, 5-8.

[14] The E in CBRNE stands for high-yield explosives, which are included when an Explosive Ordnance Demolitions (EOD) asset is added to a CBRN unit.

> …there are four basic components of each CBRNE Company Team – a company headquarters (Tech Escort (TE), Explosive Ordnance Demolitions (EOD), or conventional CBRN) for command and control and limited sustainment: chemical, biological, radiological, nuclear, and high-yield explosive response team (CRT); EOD team (three EOD Soldiers); and a "specialized" decontamination platoon. These decontamination platoons [are] outfitted with and trained on the equipment set contained in hazard response platoons currently serving in Iraq.[15]

This new organization increases the capacity for operations during both peacetime and combat. CBRNE Company Teams are able to respond to a variety of situations with specific expertise and standard operating procedures without the need for additional Chemical units. In a situation where the sheer size of the operation requires additional resources, the CBRNE Company Team has the requisite knowledge to maintain command and control of the operation.

2. Non-Traditional Operations and Capabilities

The non-traditional operations and capabilities of the Chemical Corps include Civil Support Teams, Sensitive Site Exploitation, HAZMAT operations, storage of toxic chemicals, toxic industrial material response, decontamination following natural disasters, and environmental protection.

a. Civil Support Teams

Catastrophic national crises such as the terrorist bombings in both New York City and Oklahoma City in the 1990s, and then the events of September 11, and the anthrax

[15] Lofy, "CBRNE CO TMs in Support," 5-8.

attacks of 2001 have led to improvements in our national response, culminating with the creation of the first Weapons of Mass Destruction – Civil Support Teams (WMD-CST) in 1998.[16]

The WMD-CSTs are response teams designed to assist civil authorities at domestic CBRNE incident sites by "identifying CBRNE agents and substances, assessing current and projected consequences, advising on response measures, and assisting with appropriate requests for additional support."[17] Title 10 US Code and/or Title 32 US Code status allow the teams to operate throughout the United States, its territories, and possessions. As a resource for state governors, the CSTs can be directed to respond to the intentional or unintentional release of CBRNE and natural or man-made disasters in the United States. The teams are highly trained and can coordinate across government agencies to effectively respond to and deal with the consequences following a crisis.[18]

The 2nd WMD-CST was one of the first units to conduct air sampling after the attack on the World Trade Center in 2001. Already well-networked with local and city authorities, the team provided a vital role in ensuring the safety of the responding emergency services. The team brought with it a mobile lab, mobile communications center, and HAZMAT support for the search and rescue teams. The mobile lab can test any suspect liquid, solid, or air

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[16] Headquarters, Department of the Army, *FM 3-11.22: Weapons of Mass Destruction – Civil Support Teams* (Washington, DC: 2007), 1-1.

[17] Ibid., V.

[18] Headquarters, Department of the Army, *FM 3-11.22: Weapons of Mass Destruction,* 1-1.

samples for chemical or biological substances down to parts per billion, as well as do rapid DNA sampling and chemical analysis to identify potential toxic substances. The FBI, upon the destruction of its communications equipment when the towers fell, utilized the 2nd WMD-CST's mobile communications center (Unified Command Suite).[19] That communications center directed a majority of the coordinated efforts at Ground Zero, indicating the scope of the CST's capabilities. By April 10, 2002, the 2nd WMD-CST from New York had been called to respond more than 38 times just since September 11, 2001. Frequently, the unit was requested to be on site at large public events, such as the NYC marathon, baseball playoffs, and the World Series – all attractive terrorist targets for a CBRNE attack.

b. Sensitive Site Exploitation

A sensitive site, as defined by the military manual *Special Text (ST) 3-90.15, Tactics, Techniques, and Procedures for Tactical Operations Involving Sensitive Sites,* is "… a geographically limited area with special diplomatic, informational, military, or economic sensitivity to the United States."[20] To the Chemical Corps, a sensitive site is any site that could include stored WMD or a facility used to produce or test them.

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[19] Kathleen T. Rhem, "Team Hears 'We've Been Waiting For You' When Public Safety's at Risk," *American Forces Press Service News Articles*, April 10, 2002, http://www.defenselink.mil/news/newsarticle.aspx?id=44181 (accessed March 13, 2009).

[20] ST 3-90.15, December 2002, in Pete Lofy, "Managing Sensitive Site Exploitation – Notes from Operation Iraqi Freedom," *Army Chemical Review,* September 2003.

Sensitive site exploitation has been conducted during both Operations Enduring Freedom and Iraqi Freedom. During those operations, CENTCOM designated sites that were associated with WMD as sensitive sites.

For instance, Task Force Iron Horse from the 4th Infantry Division (4ID) at Fort Hood, Texas was assigned the task of securing and exploiting many of the sites during its deployment in support of Operation Iraqi Freedom. The Task Force was responsible for checking out potential sites as directed by the 4ID Effects Coordination Cell (ECC). The ECC categorized the sites as either "potentially containing WMD" or "not containing WMD" and then prioritized them for exploitation. The Task Force quickly realized that reports from the local population regarding "things buried in their backyards, fields, or playgrounds" and incorrect identification by troops of found munitions could quickly overwhelm the unit's SSE assets which were already in high demand. The lessons learned included a need for a filter system and research of each potential site at the lowest possible level before requesting the Task Force SSE assets. This significantly reduced the strain on the sensitive site teams. The local unit would survey the site with its organic CBRN teams. Only with positive results would they request the support of the Fox M93A1 Nuclear, Biological, and Chemical Reconnaissance System and, with further positive results, would then request the support of the Task Force SSE assets.[21]

[21] Pete Lofy, "Managing Sensitive Site Exploitation – Notes from Operation Iraqi Freedom," *Army Chemical Review,* September 2003. Further examples and citations of Sensitive Site Exploitation are not available in an open-source media.

c. HAZMAT Operations

The U.S. Army is not the only branch of the government that conducts HAZMAT or CBRN operations. The Federal Water Pollution Control Act of 1972 established the National Strike Force (NSF) as a rapidly deployable resource for hazardous material (HAZMAT), petroleum, and biochemical response. The NSF is part of the existing National Response System – a network of federal, state, and local agencies that prepare for and respond to oil and hazardous substance releases, including chemical and biological terrorism incidents. The Coast Guard is a traditional member of the NSF and has trained with the Chemical Corps on HAZMAT and CBRN operations, each benefit from the other's extensive knowledge of their respective specialties.[22]

In June 2007, an Iraqi Army patrol and its American advisors (members of a Military Transition Team) discovered several thousand five-gallon containers of nitric acid – an extremely corrosive, toxic industrial chemical associated with bomb making. This led to the largest HAZMAT remediation mission undertaken during Operation Iraqi Freedom. The mission was dubbed Operation Dragon's Den, and included using sand and caustic soda to neutralize and absorb large puddles of the nitric acid before packing it into overpack containers (large drums capable of storing hazardous materials) for movement to the HAZMAT yard on Camp Fallujah. The operation also required significant decontamination operations for the personnel and equipment

[22] Dennis E. Branson and Jaime Bigelow, "The Chemical Corps and the Coast Guard – Interoperability in Action," *Army Chemical Review,* January 2003.

conducting the cleanup. This operation included CBRN Soldiers and Marines, Marine and Iraqi Firefighters, and environmental representatives from several organizations.[23]

d. Storage of Toxic Chemicals

The Chemical Corps first began storage operations of chemical munitions in the early 1960s. After a series of national policy changes in the 1980s, the focus changed from stockpiling the munitions to safely storing them until they could be demilitarized. The U.S. Army Chemical Materials Agency (CMA) is responsible for the seven locations where munitions are currently stockpiled as demilitarization continues. For instance, at the Anniston Chemical Activity (ANCA) in the Anniston Army Depot (ANAD) in Alabama the stockpiles include: rockets, artillery shells, mortars, land mines, ton containers (for storing bulk supplies of agent), the nerve agents sarin (GB) and VX, and sulfur mustard blister agents (H, HD, and HT). This facility has safely destroyed 142,428 rockets and artillery shells and 96,246 gallons of liquid GB (Phase 1), 26,491 M55 rockets and 30,301 gallons of liquid VX (Phase 2, which includes the VX filled artillery shells and land mines, scheduled for disposal next). In its final phase of operations ANCA will dispose of mustard agent artillery shells, mortars, and bulk containers. The facility has already conducted more than

[23] Vasili Karatzas and Alejandro Ibarra, “Operation Dragon’s Den,” *Army Chemical Review,* Winter 2008, 12-15.

9.5 million safe man-hours of operations and will be decommissioned at the end of the demilitarization operations.[24]

e. Toxic Industrial Material (TIM)

Experiences with the 1984 chemical release at Bhopal, India, and the 1986 nuclear contamination release at Chernobyl, Ukraine, demonstrate that toxic industrial materials can pose as many hazards as military weapons. A release other than attack, whether intentional or due to collateral damage, presents a potential challenge for our forces.[25]

For the purposes of this thesis, TIM incidents are treated as non-traditional operations. A shift in training focus has been advocated by chemical officers for the last several years to include TIM/HAZMAT training at the schoolhouse based on the prevalence of those types of scenarios in the Global War on Terror. While traditional CBRN weapons are glorified for their ability to produce mass casualties, our most likely adversaries (a state- or non-state sponsored actor) will not have access to them. However, they will have access to the means for creative attacks using toxic industrial materials.[26]

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[24] Michael B. Abrams, "Anniston Chemical Activity Stores and Demilitarizes Weapons of Mass Destruction," *Army Chemical Review,* January-June 2007, 43-44.

[25] U.S. Army Chemical School (USACMLS), *FM 3-11.3: Multiservice Tactics, Techniques, and Procedures,* I-2.

[26] James Demyanovich, "The U.S. Army Chemical Corps- An Expansion in Skills and Equipment is Needed to Support Response to TIM/HAZMAT Release Incidents," *Army Chemical Review,* April 2004, 1.

In 2003, the Commandant of the Chemical Corps added training on TIM/HAZMAT events to the Chemical School curriculum. This addition illustrates concern over the importance and likely future prevalence of these events.

> TIM hazards, previously considered insignificant during wartime, increase greatly in significance when manufactured, stored, distributed, or transported in close proximity to fixed sites, ports, or airfields. Deliberate or inadvertent release significantly increases hazards to the indigenous population and U.S. forces…TIM are generally classified in one of the following categories:
>
> - Agricultural—includes insecticides, herbicides, and fertilizers
> - Industrial—chemical and radiological materials used in manufacturing processes, in fuel, or in cleaning
> - Production and research—chemicals and biological materials produced or stored in a facility
> - Radiological—nuclear power plants, medical facilities, and laboratories[27]

But, they can also include less conventional sites and sources:

- Clandestine, illegal drug-manufacturing sites
- Lakes with runoff from industrial complexes
- Bodies of water or land suspected of sabotage
- Debris from cargo aircraft, truck, car, or railroad accidents
- Illegal toxic waste sites found on battlefields
- Large industrial spills found along avenues of commerce transportation[28]

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[27] U.S. Army Chemical School (USACMLS), *FM 3-11: Multiservice Tactics, Techniques, and Procedures,* I-8.

TIM contaminated areas can also include those devastated by natural disasters, such as Hurricane Katrina, or terrorist attacks such as September 11th.

f. Decontamination Following Natural Disasters

Floods and receding waters after hurricanes, typhoons, dam breaks, etc, can create TIM and HAZMAT events. In order for the affected populations to continue life in an affected area, decontamination must be performed. We saw this quite vividly with Hurricane Katrina in the United States in 2005.

In fact, Hurricane Katrina initiated the first decontamination operation of its type by troops in an urban situation. In order to keep up with the demand for decontamination operations, the Paratroopers from the 21st Chemical Company (Airborne) had to conduct continuous operations for eight days until the water receded enough for the unit to close its decontamination site.[29]

g. Environmental Protection

Whereas formerly the military has been accused of contributing to environmental pollution, today it is far likelier to work to help clean it up. This is especially true of land around military installations and training areas.

For instance, according to a national water quality assessment conducted between 1992 and 1999 by the

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[28] Gene Weinreis, "The Warrior Scientist: Preparing Today for Victory on Tomorrow's Battlefield," *Army Chemical Review,* Winter 2007, 20.

[29] Aimee Hemery, "The 21st Chemical Company Provides Aid in New Orleans," *Army Chemical Review, January-June 2007, 8-10.*

U.S. Geological Survey, 70 percent of domestic and public wells contain at least one form of chlorinated solvent, nitrate, or pesticide and 47 percent contain at least two compounds. Dry cleaning agents, engine degreasers, and paint removers have not only polluted the nation's groundwater but also represents one of the largest remediation liabilities for the Department of Defense.[30]

The Tarheel Army Missile Plant in Burlington, North Carolina, a former Army-owned and contractor-operated facility from the 1950s, pioneered the first remediation program for chlorinated solvent cleanup. This new technique is better, faster and cheaper than all previous techniques and uses Emulsified Oil Substrate (a food-grade soybean oil solution). The solution is diluted and "injected into the aquifer and then followed with chase water to distribute and immobilize the oil droplets. Once in the subsurface, the food grade substrates biodegrade, consuming dissolved oxygen and releasing hydrogen to stimulate reductive dechlorination."[31] Testing within weeks after the injection revealed that the chlorination had decreased by 99 percent and has remained low.[32]

That is one sort of remediation the Chemical Corps has learned to perform well. A second example is Task Force Environmental Cleanup. In late April 2003, the 2nd Brigade Combat Team from the 101st Airborne Division (Air Assault) discovered extensive chemical dumping from a looted agricultural storage facility in central Mosul, Iraq. The

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[30] Ira May and Jean Skillman, "New Technology Helps Mother Nature Expedite Cleanups," *Army Chemical Review,* July-December 2005, 14.

[31] Ibid., 15.

[32] Ibid., 16.

Division Chemical section quickly organized Task Force Environmental Cleanup to combat the more than 11,000 gallons of assorted chemicals that were deliberately poured on the ground and streets of this Mosul neighborhood. When the initial site survey team arrived to assess the situation, it discovered children vomiting and found many dead animals, including more than 20 dead pigeons. It also found that the local populace refused to evacuate their homes for fear they would be looted in their absence. In order to contain the immediate threat, 2nd Platoon of the 63rd Chemical Company (Smoke/Decontamination) conducted a complete terrain decontamination of the effected grounds and the warehouses, then capped the sites with approximately 120 tons of dirt. After repeated testing for vapor hazards (which posed the most immediate and serious threat to the local populace) the area was deemed safe. Further plans were made to remove and dispose of the contaminated soil.[33]

[33] Brian Lynch, "Task Force Environmental Cleanup," *Army Chemical Review,* September 2003.

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II. THE CREATION OF AFRICOM AND CHALLENGES IN AFRICA

The U.S. Africa Command (AFRICOM) was created to combine and take over programs previously run by the U.S. Pacific Command (PACOM), the U.S. European Command (EUCOM), and the U.S. Central Command (CENTCOM) on the African continent. All three had prior responsibility for maintaining relationships with countries in Africa, but none had responsibility for coordination of those efforts and their programs.

> The creation of U.S. Africa Command enables [the Department of Defense] to better focus its resources to support and enhance existing U.S. initiatives that help African nations, the African Union, and the regional economic communities succeed. It also provides African nations and regional organizations an integrated [Department of Defense] coordination point to help address security and related needs.[34]

A. THE CHEMICAL CORPS AND THE GEOGRAPHIC COMBATANT COMMANDS

CENTCOM's Area of Focus (AOF) includes both wars in Iraq and Afghanistan. As we have seen, during those wars the Chemical Corps has conducted limited traditional operations, but significant non-traditional operations as referenced in the previous chapter.

Throughout the Cold War, Chemical units in EUCOM maintained readiness in the event of a CBRN attack from the Soviet Bloc. Chemical units were responsible for

[34] United States Africa Command, "About US AFRICOM," *Africom.mil*, http://www.africom.mil/AboutAFRICOM.asp (accessed March 6, 2009).

traditional operations throughout the Cold War, and since the end of the Cold War have assisted in more non-traditional operations such as HAZMAT operations, environmental clean-up and protection.

As for operations in PACOM, Chemical Corps historians mostly describe traditional operations associated with the Korean and Vietnam Wars. During the Korean War, the Corps ran smoke and mortar missions. During the Vietnam War the Corps developed and used aerial "people sniffers" to find the enemy, thickened fuel flame devices to protect firebases, developed herbicides to clear fields of fire and tear gas to restrict the enemy and control crowds.[35]

Currently, there are no open-source references concerning CBRNE operations undertaken by CENTCOM, EUCOM, PACOM in Africa.

B. TRADITIONAL CBRN EVENTS IN AFRICA

As for CBRN events in Africa, Appendix A offers a chronological list spanning the last 60 years. These events do not seem to reveal any particular trends, as they include the use of poison, acid, tear gas, biological agents, explosives, and fire. The only pertinent generalization that can be made is that CBRN events seem to be centered in specific conflict zones and relate to what is locally available by way of material and components.

[35] U.S. Army Chemical, Biological, Radiological, Nuclear School, "U.S. Army Chemical Corps History," *History,* http://www.wood.army.mil/cbrns/history.html (accessed February 17, 2009).

C. NON-TRADITIONAL CBRN EVENTS IN AFRICA

In contrast, *non-traditional* CBRN events do point to certain discernable trends. Non-traditional CBRN events can include oil spills, toxic industrial material releases, and refining and mining byproducts. The pollution charges from environmental watch-groups against corporations are too numerous to list, but all contribute to a significant amount of damage done to the land and peoples of Africa.

Considering that there are abundant resources available in Africa, along with inexpensive labor, and few environmental controls there is almost limitless potential for abuse. Several negative environmental trends are readily detectable across Africa, including (in order of prevalence): deforestation, erosion, drought, desertification, potable water scarcity, raw sewage pollution, poaching, overgrazing, oil/industrial water pollution, silt pollution, and flooding. Appendix B lists African countries along with their resource and environmental issues. Of those issues, this thesis now turns to several that the Chemical Corps either has the current capability, or could develop the capability, to assist with.

1. Oil and Industrial Pollution

> *The River Niger's Delta region in southern Nigeria (West Africa) is the major oil-producing area of sub-Saharan Africa, with a crude oil production of 2.04 [million barrels per day]. This region has been environmentally altered in the last 40 years by the oil industry boom. It is calculated that over 95% of the former rainforest has now disappeared, and that over 5800 km of oil pipelines have been built*

> *throughout the Delta since 1958, many of which have been repeatedly broken, causing catastrophic oil spillages. For instance, between 1986 and 1996 there were 2796 cases of oil spills in this region, totaling about 2,500,000 barrels of oil spread across the natural environment.*[36]

a. The Curse of the World's Most Valuable Resource

The discovery of oil brings money, power, and international assistance. Oil also brings with it destruction, poverty, war, corruption, and environmental devastation.

Communities along the Niger Delta have lived off subsistence fishing and agriculture for decades. Neither of those food sources are viable when an oil spill occurs.

> The waterways and mangroves are blanketed in thick brown sludge that goes on for miles. Toxicity overpowers the air and a sense of lifelessness pervades the landscape. Many say it will take 10-15 years for the area to be free of contamination – if the cleanup effort commences in a timely manner.[37]

Oil has consistently proven a curse for a majority of Nigerians. Since the 1970s, the United Nations estimates there have been more than 6000 oil spills in the Niger

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[36] L. Luiselli and others, "Home range area may vary considerably in relation to habitat contamination in two African terrapins from pristine and oil polluted habitats," *Amphibia-Reptilia* 27 (2006): 255.

[37] Ling, "World's Most Valuable Resource."

Delta.[38] Despite this vast number, there is little international outrage and seldom are the spills reported, even in Nigeria.[39]

As of 2007, there are over 606 oil fields.[40] Despite the fact that oil revenues have transformed the Nigerian economy, the Niger Delta region itself remains the most underdeveloped and backward in Nigeria in terms of human capital, industrial infrastructure, and basic social services. This backwardness "has been exacerbated by environmental degradation and pollution by oil firms that have turned farmlands into wastelands. Loss of farmlands means loss of income and source of livelihood and sustenance. The region is a classic case of blatant neglect in the midst of its phenomenal oil wealth."[41] Not only do oil spills damage the land, making it unusable for farming, but they also kill the marine life, devastating the communities that depend on subsistence fishing.

While pollution is one of many secondary or even tertiary effects of oil exploration, other effects include: logging to clear areas for pipelines, tank farms, and other oil activities; gas flaring – known to be responsible for acid rain; sabotage by locals who feel cheated of the benefits from extraction of resources on their land; erosion due to deforestation; and low-yield crops from contaminated soil.

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[38] Ling, "World's Most Valuable Resource."

[39] Ibid.

[40] Felix M. Edoho, "Oil Transnational Corporations: Corporate Social Responsibility and Environmental Sustainability," *Corporate Social Responsibility and Environmental Management 15,* no.4 (2007): 216.

[41] Ibid.

2. Floods and other Natural Disasters

Portions of the African continent repetitively experience floods and droughts. Several countries are particularly prone to these cycles: South Africa, Zimbabwe, Mozambique, Malawi, Zambia, and Namibia. For example, in 2001, 7000 people died in floods in Mozambique. In 2007, over 50 deaths were recorded, while in 2008 there were less than a dozen fatalities.[42] Nevertheless, all these floods destroyed tree crops, inundated crops, ruined forests, destroyed villages, and created repeat humanitarian crises.

a. Contaminating the Water-table

Flooding typically contaminates the water-table; increases waterborne diseases; assists in spreading other diseases such as malaria, cholera, dysentery, and tuberculosis; and spreads pollution across a greater area. Almost half of Africa's countries cite water contamination from silt, raw sewage, or oil/industrial pollution. Even more claim their available water is not safe for drinking. Several nations also report that they have little-to-no fresh water access, potable or otherwise.[43]

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[42] "More Floods, Drought in Africa," *news24.com,* September 7, 2008, http://www.news24.com/News24/Technology/News/0,,2-13-1443_2354550,00.html (accessed March 6, 2009).

[43] CIA, *The World Factbook* (2009), https://cia.gov/library/publications/the-world-factbook/geos/bn.html#Geo (accessed March 14, 2009).

3. Dumping

a. "Donated" Insecticides

There have been several instances of toxic dumping masked by the perpetrators as international aid. Many nations use Africa as an inexpensive dumping ground, promising assistance with the acceptance of their toxic waste. In one documented case, the government of Niger sent a shipment of the toxic chemical dieldrin back to the Netherlands. The chemical had originally been "donated" to Niger as a pest control product and, when it proved ineffective against insects, the government realized it had been duped. Countries have also been known to try to bribe recipients into accepting toxic waste. For example, Japan donated Toyota trucks to Benin provided Benin also accept shipments of highly toxic chemicals.

Many times the 'donated' pesticides cannot be used since they are ineffective. Stored improperly, they leak into the water-table and poison some of the little available water. To make matters worse, several international organizations, both aid organizations and chemical corporations, are working together on plans for incineration facilities within Africa, which would in effect keep the chemical donations coming. Once incinerated, the chemicals would become toxic emissions and poisonous ash, further destroying the African environment.[44]

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[44] Holley Knaus, "Return to Sender," *The Multinational Monitor* 12, no. 9 (1991), http://www.multinationalmonitor.org/hyper/issues/1991/09/lines.html (accessed January 19, 2009).

In late 2006, tons of toxic chemicals were illegally dumped around the Cote d'Ivoire port city of Abidjan when the trucks transporting them were denied access to the local dump due to their fumes. The waste had originated aboard a ship that had picked up a load of low-grade gasoline and then refined it, creating a by-product of toxic waste. Typical procedures dictate that upon delivery of the gasoline to their destination, the ship's waste tanks must be cleaned out to the tune of $300,000 in Europe or $12,000 in Africa. What is done with the waste is up to the company that agrees to clean out the tanks. The shipment of gas arrived in Cote d'Ivoire and, upon emptying the tanks and beginning the process of transporting the waste to the dump, locals living near the dump barricaded the entrances forcing the trucks to go elsewhere, at which point they began dumping around the city, or just abandoned the full trucks on the side of the road. The dumping led to reports of thousands of people suffering from vomiting, diarrhea, and nosebleeds.[45]

b. "Donated" E-Waste

A looming problem presents itself with the donation of used electronics, primarily cell-phones, computers and televisions, to developing nations under recycling programs. Regulations state that the donating countries are not required to prove that the electronics are functional, thereby providing an easy loophole for dumping. According to the Basel Action Network, a Seattle-based

[45] Kimberly Johnson, "Toxic Dumping in Africa Elicits Calls for Better Controls," *The National Geographic News*, October 30, 2006, http://news.nationalgeographic.com/news/2006/10/061030-toxic-waste_2.html (accessed January 19, 2009).

environmental group, 75 percent of all recycled electronics can't be repaired and end up in landfills and dumps in countries such as Nigeria. One problem with this is that most e-waste contains toxic materials such as lead, cadmium, and mercury, which leech into the water table. Additionally, the popular way to decrease the size of the piles of plastic casings is to burn them, releasing multiple carcinogens into the environment. While some profit can be gleaned from disassembling the components for scrap metal parts and reconstruction of some working electronics, the workers who disassemble the parts are the most likely to experience carcinogenic effects the soonest, primarily women and children.[46]

4. Mining and the African Water-table

There are many metals and minerals in addition to fuels extracted in Africa, such as: aluminum, bauxite, copper, gold, iron ore, lead, nickel, platinum, zinc, titanium, diamonds, phosphate rock, coal, and uranium.[47] Many of these extractive operations require huge quantities of water for processing the products, which then, mixed with chemicals, seep back into the water-table. Erosion and silt are by-products of mining that engorge rivers and streams, and decrease the capacity to support life. Tailings (the grainy-sludgy residue) from strip-mining are virtually

[46] Ben Harder, "Toxic 'E-Waste' Gets Cached in Poor Nations, Report Says," *The National Geographic News*, November 8, 2005, http://news.nationalgeographic.com/news/2005/11/1108_051108_electronic_waste.html (accessed January 19, 2009); Charles W. Schmidt, "Unfair Trade: e-Waste in Africa," *Environmental Health Perspectives* 114, no. 4 (2006), http://www.ehponline.org/members/2006/114-4/spheres.html (accessed January 19, 2009).

[47] "Mineral Industry in Africa" *Wikipedia.com, http://en.wikipedia.org/wiki/Mining_in_Africa (accessed March 6, 2009).*

devoid of life. They have no mineral or organic value, so using tailings as dirt for planting is out of the question – they can also have a high toxin content and contribute to acid rock drainage.

a. Hydropolitics

Water is essential to the cycle of life. However, on a continent where water is a scarce commodity it takes on a life of its own through hydropolitics. The water issues pertaining to four of the most developed nations in Africa – South Africa, Botswana, Namibia and Zimbabwe - stem from the discovery of gold and diamonds in the late 1800s.

Johannesburg, South Africa, is one of the few major cities of the world that does not lie on a river, a lake, or a seafront. When gold was originally discovered, the mining process used huge volumes of water for panning to find additional gold. However, a few years later, a more precise method was introduced producing higher gold yields. This was the McArthur Forester process, which uses cyanide to chemically separate the gold from other minerals.[48]

> Given that the majority of the mining operations have occurred along the Witwatersrand Ridge, the water table has been substantially reduced due to mine dewatering activities. Water arising from mining operations tends to come into contact with the residue of the mining operation such as dust, exposed reef, and waste rock. Depending on the type of minerals being mined, this water dissolves chemical substances in that residue. When sulphite ores, particularly those containing pyrite (often associated with gold-bearing reef)

[48] Anthony Turton and others, "Gold Scorched Earth and Water: the Hydropolitics of Johannesburg," *Water Resources Development* 22, no. 2, (2006): 319.

> come into contact with a combination of air and water, they give off sulphur dioxide and produce low pH waters with a high concentration of iron and sulphate. This process is accelerated by specific groups of bacteria that help to transform inert sulphides into acidic solutions. This problem is of a significant magnitude, particularly when mines reach the end of their useful lives and are closed, known as acid rock drainage.[49]

The acid rock drainage ends up in the local water supply. When the entire water supply is connected then the entire region is affected. Livestock, people, and the environment in general suffer. While there are processes to clean the water for consumption, they cannot keep up with the demand and the poor cannot afford to buy clean water.

Southern Africa is not the only region of Africa where waterways are polluted through mining. The Pra River Basin in Ghana, West Africa has had significant damage from the use of metallic mercury to extract gold from crude ore since the 4th century.[50] The damage comes from the processing of ores and disposal of tailings and wastewaters around mines, all of which negatively affect the surrounding river systems.

> Despite the alarming findings on the negative impacts of [metallic mercury] on human health and the environment, small-scale gold mining by [metallic mercury] amalgamation in gold-rich countries of South America, Asia, and Africa is a growing and widespread economic activity. Therefore, the contamination of soils, sediments, water and biota by heavy metals has become a

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[49] Anthony Turton and others, "Gold Scorched Earth and Water," 328.

[50] Augustine K. Donkor and others, "Heavy Metals in Sediments of the Gold Mining Impacted Pra River Basin, Ghana, West Africa," *Soil and Sediment Contamination* 14 (2005): 480.

> primary concern in these new mining sites because of their toxicity, persistence, and accumulation in food chains.[51]

Lake Victoria in East Africa has been the focus of several studies on mercury poisoning and pollution in the last 20 years. The economies surrounding Lake Victoria rely on the fisheries and particularly the export of fish to the European Union.[52] This dependence has stimulated a series of studies focusing on mercury levels in the fish and in the lake. [53]

Mercury is an element which compounds in systems; a plant can assimilate mercury from the ground and, when burned, releases the mercury into the atmosphere which in turn precipitates into the lake and poisons the fish. The big fish eat the smaller fish, increasing the amount of mercury in their systems. The fish are then caught and eaten, which in turn further poisons the people as they are also gaining mercury from the plants and water they are consuming.

Globally, 50 percent of the fires seen in satellite observations are located in sub-Saharan Africa indicating that biomass burnings are another source of

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[51] Augustine K. Donkor and others, "Heavy Metals in Sediments of the Gold Mining Impacted Pra River Basin, Ghana, West Africa," *Soil and Sediment Contamination* 14 (2005): 480.

[52] Republic of Uganda, 1999, *State of the environment report for Uganda 1998*, Kampala: National Environmental Management Authority, in Linda M. Campbell, D.G. Dixon, R.E. Hecky, "A Review of Mercury in Lake Victoria, East Africa: Implications for Human and Ecosystem Health," *Journal of Toxicology and Environmental Health,* Part B, 6 (2003):326.

[53] Linda M. Campbell, D.G. Dixon, and R.E. Hecky, "A Review of Mercury in Lake Victoria, East Africa: Implications for Human and Ecosystem Health," *Journal of Toxicology and Environmental Health,* Part B, 6 (2003):326.

potential mercury poisoning of African lakes.[54] Soil erosion is yet another source of mercury, as it is quickly released upon contact with water.[55]

5. Mining Uranium and Radiation

The CIA World Factbook lists sixteen African nations as having uranium. (See Appendix B). Mining uranium releases radioactive gases and dust into the environment, which should be closely monitored. Niger and Namibia are two examples of countries that have had populations with symptoms of radiation poisoning including lung cancer, tuberculosis, and a range of skin diseases. In one case, at the 40-year-old mine in Arlit, Niger it was found that "no protection measure was taken for workers, neither protective equipment not masks, exposing workers to the deadly gases" over the course of 15 to 20 years.[56] Locals report that in 2004 a truck carrying uranium ore was involved in a

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[54] E. Dwyer and others, "Global spatial and temporal distribution of vegetation fire as determined from satellite observations," *Int. J. Remote Sensing* 21:1289–1302, in Linda M. Campbell, D.G. Dixon, R.E. Hecky, "A Review of Mercury in Lake Victoria, East Africa: Implications for Human and Ecosystem Health," *Journal of Toxicology and Environmental Health,* Part B, 6 (2003):325-356. Linda M. Campbell, "Mercury in Lake Victoria, East Africa: Another emerging issue for a beleaguered great lake?" PhD thesis, Department of Biology. University of Waterloo, Waterloo, ON, Canada, in Linda M. Campbell, D.G. Dixon, R.E. Hecky, "A Review of Mercury in Lake Victoria, East Africa: Implications for Human and Ecosystem Health," Journal of Toxicology and Environmental Health, Part B, 6 (2003):325-356.

[55] M. Roulet and others, 1998. "The geochemistry of mercury in central Amazonian soils developed on the Alter-do-Chão formation of the lower Tapajós River Valley," in Linda M. Campbell, D.G. Dixon, R.E. Hecky, "A Review of Mercury in Lake Victoria, East Africa: Implications for Human and Ecosystem Health," *Journal of Toxicology and Environmental Health,* Part B, 6 (2003):325-356.

[56] The United Nations, "NIGER: Residents of Uranium Mining Town Fear They're Being Exposed to Radioactive Poisoning," *Irinnews.org* (April 28, 2005), http://www.irinnews.org/report.aspx?reportid=54130 (accessed March 16, 2009).

collision. The resulting spill on the road was not properly cleaned up and one month afterward radiation levels were still ten times higher than normal.[57]

The statement that "no one cares about Africa" seems to have pervaded the business practices of many foreign corporations, and even some indigenous corporations, operating there. One testament to the disregard for Africa is the lack of attempts to either cover-up or admit to and clean up chronic pollution. It seems that only once a watch-group has brought attention to a major problem is it even remotely addressed.

These are precisely the events that the Chemical Corps can assist with via remediation.

D. ENVIRONMENTAL DEGRADATION AS A SECURITY THREAT

> *Climate change represents the latest in a series of environmental drivers of human conflict that have been identified in recent decades, following others including drought, desertification, land degradation, failing water supplies, deforestation, fisheries depletion, and even ozone depletion … Climate change is now being recast as a threat to international peace and security; and the region seen as most likely to suffer its worst effects is Africa.*[58]

AFRICOM has already begun programs working with African governments to address environmental degradation as a security threat. Efforts are being made by AFRICOM and its

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[57] The United Nations, "NIGER: Residents of Uranium Mining Town."

[58] Oli Brown, Anne Hammill, and Robert McLeman, "Climate Change as the New Security Threat: Implications for Africa," *International Affairs* 83, no. 6 (2007): 1141.

African partners to stabilize conflicted regions with consideration for the role that the environment plays in stability.

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III. CHEMICAL CORPS APPLICATION WITHIN AFRICOM

Given the roles and missions of the Chemical Corps, and the issues reviewed here, what might the Chemical Corps do in Africa?

A. AFRICOM'S CURRENT OPERATIONS

Currently, AFRICOM is conducting several operations in which the Chemical Corps can easily acquire an active role.

First is the State Partnership Program. As of early 2009, seven U.S. states' National Guard units have each partnered with an African nation for training, exercises, and relationship building.[59] The Civil Support Teams are a part of the U.S. National Guard, as each state's WMD response team. With just over fifty Civil Support Teams and just over fifty nations in Africa, each team could theoretically partner with a country and conduct HAZMAT, TIM, and decontamination training.

Second are disaster preparedness training exercises such as "Natural Fire."[60] Natural Fire is a 2009 multilateral, regional, disaster relief exercise conducted with the Rwandan, Burundian, Ugandan, Kenyan, and Tanzanian militaries in conjunction with AFRICOM's Army Component, US

[59] United States Africa Command Brief, "State Partnership Program," *Africom.mil* (March 2009), http://www.africom.mil/pdfFiles/AFRICOM%20Deputies%20Cmb%20Brf%20Industry%20Day%202008%2004%2030.pdf (accessed March 16, 2009).

[60] Ibid.

Army Africa (USARAF).[61] As discussed in the previous chapter, the Chemical Corps has several capabilities that can be applied to disaster relief operations. For instance, they could conduct decontamination operations for the first responders and search and rescue personnel, as they did after Hurricane Katrina. They could also conduct reconnaissance of potential TIM contamination sites, due to the disaster. If any TIM contamination sites were found, they could conduct cleanup of those sites. Each of these disaster relief capabilities can be cross-trained with the Rwandan, Burundian, Ugandan, Kenyan, and Tanzanian militaries. The training could start with train-the-trainer instruction at the CBRN Schoolhouse at Fort Leonard Wood, Missouri, followed by more in-depth training in-country with Mobile Training Teams (MTTs), and then, after military-to-military training with each individual nation, Natural Fire could be the culmination exercise to test everyone's capabilities.

Third is the Africa Contingency Operations Training and Assistance (ACOTA) program. This program trains African peacekeepers in, among other things, humanitarian operations. Some of the same capabilities used in the disaster preparedness training exercises can be taught to humanitarian peacekeepers. As illustrated by Appendix A, occasionally toxins, poisons, and industrial chemicals are used against people during conflicts. The humanitarian peacekeepers should have some sort of training in neutralization of toxins and protection and decontamination

[61] United States Africa Command: 2009 Posture Statement, "East Africa," *Africom.mil* March 2009, http://www.africom.mil/pdfFiles/USAFRICOM-Posture-Statement-Booklet-17Mar09-FINAL.pdf (accessed March 25, 2009) 28.

of the victims and the peacekeepers assisting the victims. Additionally, the Chemical Corps can train peacekeepers in water-testing techniques and procedures when new wells are drilled as part of humanitarian operations.[62]

Finally, the Africa Partnership Station (APS) presents a unique opportunity for the Chemical Corps. It incorporates a U.S. Navy ship that sails from port to port training military personnel in subject areas such as seamanship, search and rescue operations, law enforcement, medical readiness, environmental stewardship, and small-boat maintenance. The purpose is to foster partnership and collaboration to achieve common goals.[63] The Chemical Corps could take the lead on environmental stewardship and include such areas as environmental clean-up of waterways, decontamination of maritime vessels, and CBRN defensive training for the ports. As of 2008, the APS had engaged 15 West and Central African nations, conducted over 1700 sessions of courses of instruction, and is comprised of professionals from eleven countries, three U.S. services (Navy, Marines and Coast Guard), and multiple agencies.[64]

Due to concerns regarding toxic industrial chemical attack vulnerabilities in South Africa during the 2010 Soccer World Cup, the government is adding significant WMD

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[62] United States Africa Command Brief, "State Partnership Program."

[63] "Africa Partnership Station," *Africom.mil,* http://www.c6f.navy.mil/aps_web/index.htm (accessed March 16, 2009).

[64] United States Africa Command, "FACT SHEET: Africa Partnership Station," (Stuttgart, Germany, January 28, 2009), http://www.africom.mil/getArticle.asp?art=2510 (accessed March 16, 2009).

response capabilities to the military.[65] The Chemical Corps could assist with training those capabilities both at the CBRN Schoolhouse and with MTTs in South Africa. Few nations in Africa have extensive WMD/HAZMAT/TIM response capabilities. In order to adequately assist with training African forces in these areas, a thorough classified assessment needs to be done of each nation's current capabilities. The assessment needs to be classified in order to be complete and honest. This will most accurately enable AFRICOM and the Chemical Corps to focus efforts where they can be of most help.

Currently, the Chemical Corps trains officers and soldiers from other nations in CBRN operations at the U.S. Army CBRN School at Fort Leonard Wood, Missouri. This program could be expanded to include teams from African nations that require specific training in a certain area. It could involve shadowing a Civil Support Team and train-the-trainer opportunities.

B. TRADITIONAL OPERATIONS

There are several instances of traditional operations in which the Chemical Corps can assist with the education and training of African militaries and civilian response teams for AFRICOM.

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[65] "World Cup Could Face CW Threat, South Africa Says," *Global Security Newswire, (*May 15, 2008), http://www.globalsecuritynewswire.org/gsn/GSN_20080515_AFE94FC0.php (accessed March 27, 2009)

1. Passive Defense

The Chemical Corps can assist countries with radiological accountability issues in gaining greater security mechanisms to protect and account for their radioactive material. This can include not only the uranium that is mined throughout Africa, but other less common radioactive sources.

The Corps can help build on the knowledge of South Africans with regard to passive defense against a nuclear meltdown at the Koeberg Reactor. As other nations gain interest in acquiring nuclear energy, the training can be expanded to include the local populations in those countries as well.

Local police and firefighters can be cross-trained on decontamination procedures throughout Africa in order to limit exposure during CBRN incidents. This could be done through train-the-trainer training and MTTs at the regional level, maybe even at the sub-regional level such as with the Economic Community of West African States (ECOWAS), the Southern African Development Community (SADC), and appropriate sub-regional entities in East Africa, and the Maghreb (North Africa), who could then train local teams. A National Response Task Force can also be set up at the regional level to deal with events on a larger scale than the local authorities can handle.

Based on Appendix B, a majority of countries in Africa have at least one need for this type of defensive training and protection. That need may not be response preparation for an outright attack, but an accidental

nuclear meltdown, accidental release of toxic chemicals, or reaction to a natural disaster.

2. Consequence Management

Consequence management should be taught at all levels of government, from the village to the national level. It can include crisis planning and scenarios for the most likely events for each region. Consequence management can also include awareness training for the effects of continued environmental degradation through soil erosion and soil and water contamination.

3. Non-traditional Operations

The capacity for non-traditional operation training is enormous within Africa, especially since there is a push within the Corps toward a wide array of hard-science focused missions which no one else is as well equipped to handle.

a. Civil Support Teams

A variation on the Civil Support Team can be introduced and trained to deal with HAZMAT clean-up and storage, and environmental clean-up and protection. A properly trained and equipped Civil Support Team can be the first responder to a natural disaster and provide immediate support until other agencies can safely arrive. Countries which may have a need for HAZMAT training include: Angola, Republic of the Congo, Cote d'Ivoire, Egypt, Liberia, Malawi, Morocco, Nigeria, Niger, South Africa, Tunisia, Zambia, and Zimbabwe.

Many African countries are chronically afflicted with floods. A Civil Support Team could be a first responder and provide immediate decontamination for the humanitarian relief workers and governmental agencies responding to the flood. Equipment and training for each team would be based on the scenario likelihood for its area. The Chemical Corps could conduct further research and development into equipment appropriate for the host nation for future use.

b. Sensitive Site Exploitation (SSE)

Sensitive site exploitation can be taught to teams in the host-nation's military as well as local and national authorities in order to help gain control of any "found" radiological materials, and to more effectively contain incidents. SSE skills can help authorities deal with the aftermath of non-state actors who may take refuge within their borders, and may bring any variety of CBRN/TIM weapons with them.

c. Toxic Industrial Material

Toxic industrial material handling and storage training would be invaluable in Africa. With adequate training, countries could safely clean up environmental hazards left by international corporations. If local militaries had this capability and expertise, this would demonstrate to citizens that their government cares about their well-being.

d. Environmental Protection

The Chemical Corps can help African nations clean up water supplies and help provide safe water sources. While the actual construction of water-collection devices is outside of the realm of CBRN operations, water testing and filtration can be conducted by the Chemical Corps.

e. Storage of Toxic Chemicals

The Chemical Corps can provide expertise in selecting sites for storage of toxic chemicals, safe handling practices, and training in neutralization techniques. Cote d'Ivoire and the toxic chemicals dumped around the city of Abidjan represent a good example of how this training would be useful. Had the chemicals been safely containerized, neutralized, and stored at a pre-selected site countless people would not have become ill.

C. FUTURE DEVELOPMENT OF THE CHEMICAL CORPS FOR OPERATIONS IN AFRICA

As the U.S. Army already trains with the U.S. Navy, Coast Guard, Air Force, and Marines in CBRN tactics, techniques, and procedures, as well as gleaning other Services' knowledge at the CBRN School, the Corps can further put that knowledge to use in finding solutions for the plethora of non-traditional challenges to be found in Africa.

Equipment for these operations would have to accommodate current resource constraints and sustainability issues in Africa. For example, a water-intensive decontamination site would not be useful in an arid nation where water is scarce.

IV. CONCLUSION

While the U.S. is not the only country with a Chemical Corps, we are the only nation with a Geographic Combatant Command centered on Africa.

Given that a main focus of AFRICOM is to build partner capacities the training the Chemical Corps can provide should assist the realization of those partner capacities.

> The creation of U.S. Africa Command does not mean the U.S. military will take a leading role in African security matters, nor will it establish large U.S. troop bases. Rather, Africa Command is a headquarters staff whose mission entails coordinating the kind of support that will enable African governments and existing regional organizations, such as the African Standby Force, to have greater capacity to provide security and respond in times of need. Africa Command builds on the many African-U.S. security cooperation activities already underway, yet will be able to better coordinate DoD support with other U.S. government departments and agencies to make those activities even more effective.[66]

The Chemical Corps has a substantial role to play in the future operations of the United States Africa Command beyond the Corps' current mission set.

A. FOR FURTHER STUDY

Appendix B draws on only a single source, the CIA World Factbook, for its information. More rigorous research would need to be done to substantiate the information presented, and to draw up a list of prioritized actions.

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[66] United States Africa Command, "About US AFRICOM," *Africom.mil*, http://www.africom.mil/AboutAFRICOM.asp (accessed March 6, 2009).

Further study into each country's resources and environmental damage can yield a more detailed list of nations that the Chemical Corps can assist. Survey teams could be sent to each country to conduct joint research with the local military into what that particular country's requirements would entail.

There are issues that will factor into any assessment, such as: accessibility, feasibility, cost, manpower and equipment requirements, training levels and locations (e.g. should training be conducted primarily at Fort Leonard Wood at the CBRN Schoolhouse or would it be more beneficial to have MTTs in country?), etc. These issues will vary both by country and by environmental region.

Further research could also create a more comprehensive and detailed, even definitive database of traditional and non-traditional CBRNE events in Africa. This database could be analyzed for trends that will assist in avoidance of and protection against future CBRNE events and potentially help African governments write policies to help protect their land and people from environmental degradation.

Teams could pair CBRN experts with African military leaders to determine what the goals and priorities should be for each African country from Africans' perspective. This will ensure that AFRICOM meets the expectations of the African militaries and matches these to existing and practicable/realistic capabilities. Given AFRICOM's objectives for operations the Chemical Corps' seems ideally poised to contribute its services and expertise.

If AFRICOM and the Chemical Corps work together both should be able to assist African countries in meaningful ways, for the greater good of not only Africans, but the world as a whole.

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APPENDIX A

A. CHEMICAL, BIOLOGICAL, RADIOLOGICAL, NUCLEAR (CBRN) HISTORICAL EVENTS IN AFRICA

Below is a list of CBRN events dating between 1950 and 2009. Unfortunately, this list, while the most comprehensive currently available in open source media, is not complete. For instance, throughout this period, radioactive material has gone missing: "The petroleum industry is the main user of radioactive material in Nigeria. The materials, which are in tools to detect cracks in pipelines and measure exploratory oil wells, have gone missing – or been stolen – in the past."[67]

1. Events from 1950-2009

a. 1952 – Livestock Poisoning – Kenya

The Mau Mau Uprising of 1952 to 1960 was an insurgency by Kenyan rebels (primarily from the Kikuyu tribe) against British colonial rule. The British have alleged that throughout the insurgency the Mau Mau rebels frequently poisoned cattle as part of a larger effort to target livestock, principally using arsenic. In 1952 alone, British authorities claimed that rebels used plant toxins to kill 33 steer at a mission station in the tribal area

[67] Bashir Adigun, "Nigeria Can't Adequately Store, Track its Radioactive Material, Says Country's Nuclear Chief," *International Herald Tribune,* July 26, 2007, http://www.iht.com/articles/ap/2007/07/26/africa/AF-GEN-Nigeria-Nuclear.php?page=2 (accessed March 6, 2009).

reserved for the Kikuyu tribe.[68] The symptoms the steer developed were synonymous with exposure to the African Milk Bush (aka Pencil Cactus). The Milk Bush's sap contains a vesicant[69] that is irritating to the skin and toxic when ingested. The steer developed large amounts of fluid inside their body cavities, which caused swelling and subsequently death.

b. 1973 – Ammonia Leak – South Africa

On 13 July 1973, a storage tank in Potchefstroom, South Africa, released 38 tons of ammonia into the local environment. The liquid anhydrous ammonia was used as fertilizer and stored either at room temperature under pressure or at atmospheric pressure and maintained at subzero temperatures. In this particular plant in South Africa, the ammonia was stored under pressure in four 50-ton horizontal cylinders. One of the cylinders exploded while being filled from a rail car. Eighteen people were killed during the explosion and subsequent gas cloud, and an additional 65 people were treated at a local hospital.[70]

c. 1976-1980 – Biological Agents – Zimbabwe and Mozambique

W. Seth Carus cites evidence suggesting that the Rhodesian government may have used biological agents against

[68] W. Seth Carus, "Bioterrorism and Biocrimes: The Illicit Use of Biological Agents since 1900," Fredonia Books, 2002, in Hamid Mohtadi and Antu Murshid, "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005," National Center for Food Protection and Defense, Jul. 7, 2006, 6.

[69] Vesicants are substances that cause tissue blistering.

the black civilian population in Rhodesia and Mozambique. Many of these accounts are based on interviews of former members of the Central Intelligence Organization (CIO). It is alleged that the CIO recruited faculty members at the University of Rhodesia to help develop and test various biological agents on members of the black population in Mozambique and Zimbabwe. In one incident in 1976, an unidentified bacteriological agent was used to contaminate boreholes, rivers, and water sources in Mozambique. This incident corresponds with a cholera epidemic, which resulted in an unknown number of casualties. In another incident, anthrax bacterium may have been introduced into rural areas of Western Zimbabwe. This coincides with the worst-ever recorded outbreak of human anthrax, which resulted in 10,738 documented cases and 182 deaths between 1979 and 1980.[71] The spike in the number of anthrax cases is certainly suspicious. In the previous 30 years, there had only been 334 reported cases overall among humans. Moreover, the geographical pattern of the outbreak is unusual, in the sense that it was widespread, but at the same time confined

[70] John Frederick Lancaster, *Engineering Catastrophes: Causes and Effects of Major Accidents*, 2nd Ed. (CRC, Abington Publishing, 2000), 180-181.

[71] Hamid Mohtadi and Antu Murshid, "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005," National Center for Food Protection and Defense, Jul. 7, 2006, 6; Ian Martinez, "The History of the Use of Bacteriological and Chemical Agents During Zimbabwe's Liberation War of 1965-1980 by Rhodesian Forces," *Third World Quarterly* 23, no. 6 (2002): 1159-1179.

to Tribal Trust Lands.[72] However, there is also speculation that the outbreak could have been derived from natural causes and not terrorism. Most experts agree that the outbreak could be attributed to the breakdown of vaccination practices in the Tribal lands. Moreover, the case for deliberate transmission of the disease is undermined given the sheer magnitude of the epidemic, which covered such a vast geographical region.[73]

d. 1 Oct 1979 – Poison Gas – Libya

In Tripoli, a high-ranking Fatah commander, Abu Khaled Sulayman, narrowly escaped serious injury after opening a letter containing poison gas.[74]

e. 8 Jan 1982 – Explosives – South Africa

On 8 January 1982, the 70th anniversary of the formation of the African National Congress, guerillas attacked the Koeberg nuclear power plant while it was still under construction. Reports disagree about the munitions

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[72] M. Wheelis, 2003,. "A Short History of Biological Warfare and Weapons," in *The Implementation of Legally Binding Measures to Strengthen the Biological and Toxin Weapons Convention*, (eds.) M.I. Chevrier, K. Chomiczewski, M.R. Dando, H. Garrigue, G. Granasztoi and G.S. Pearson, Amsterdam: ISO Press, pp. 15-31. In Mohtadi, Hamid, and Antu Murshid. "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005," National Center for Food Protection and Defense, July 7, 2006, 11.

[73] Ibid.

[74] Hamid Mohtadi and Antu Murshid, "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005." National Center for Food Protection and Defense, Jul. 7, 2006, 15. The article references the National Memorial for the Prevention of Terrorism, *Terrorism Knowledge Base*, http://www.tkb.org, however, this incident cannot be found on their database. There are, however, extensive articles from multiple sources related to the creation and stockpiling of nuclear, biological, and chemical weapons by Libya from the mid-1970s to the mid-2000s.

used for the attack and most indicate that the attackers utilized bombs, mines, or SA-7 missiles. The completion of the power plant was pushed back 18 months due to damage.[75]

f. Aug 1989 – Biological Agents – Namibia

There are several reports of an August 1989 attack on the water supply at Dobra, a refugee camp in Namibia, by the Civil Cooperation Bureau, South Africa's covert Special Forces organization during the apartheid era. The operative ordered to conduct the attack stated that he was given cholera and yellow fever organisms by a South African Army doctor, but the attack failed due to the high chlorine content in the water supply.[76]

g. 17 Mar 1990 – Fire – Libya

The Rabta "Technology Center" by late 1989 was producing a wide variety of chemical weapons, including blister and nerve agents. In March 1990, U.S. intelligence sources indicated that a massive fire had occurred at the center leading to indefinite suspension of the production of all agents. However, by May 1990 production had resumed. It is speculated that production of the agents had actually moved to another nearby facility and the fire reports were a

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[75] Helen Bamford, "Koeberg: SA's Ill-Starred Nuclear Power Plant," *Independent Online,* March 11, 2006, http://www.iol.co.za/index.php?set_id=1&click_id=13&art_id=vn20060311105842482C822914 (accessed February 15, 2009).

[76] Helen E. Purkitt and Stephen F. Burgess, *South Africa's Weapons of Mass Destruction,* (Indiana: Indiana University Press, 2005) 152.

hoax. President Qaddafi accused the United States and other western nations of involvement in the fire. No allegations were substantiated.[77]

h. May/Jun 1999 – Tear Gas – South Africa

There are several incidents regarding the use and theft of tear gas in mid-1999 in South Africa. While tear gas is on the low-end of the scale with regard to chemical agents, it falls into the category of a riot control agent. It can be lethal in concentrated doses in closed quarters. In the South African cases in 1999, one involved the arrest of four men with 10 canisters of tear gas in their possession. Another consisted of a white policeman spraying a black colleague with tear gas, and a third consisted of several boys stealing weapons to include tear gas from the police.[78]

i. Jan 2000 – Acid – Nigeria

Throughout the early 2000s there are scattered reports of acid being used as a weapon throughout Africa. Acid appears to have been the weapon of choice for the Odua People's Congress of Nigeria. The group had, on several occasions, used various acids in attacks on police officers and opposing factions. The Odua People's Congress, which

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[77] Global Security, "Rabta [Pharma 150]," *Weapons of Mass Destruction (WMD),* http://www.globalsecurity.org/wmd/world/libya/rabta.htm (accessed February 15, 2009).

[78] Gavin Cameron and others, "1999 WMD Terrorism Chronology: Incidents Involving Sub-National Actors and Chemical, Biological, Radiological and Nuclear Materials," *The Nonproliferation Review* 7, no.2 (2000).

represents Nigeria's Yoruba ethnic group, had taken the lead in instigating violent ethnic eruptions in southwestern Nigeria.[79]

j. 21 Feb 2000 – Poison – Nigeria

In late February, riots broke out in the northern city of Kaduna in Nigeria. These would be the first of many riots in reaction to the introduction of Sharia Law. Although Sharia Law was only supposed to apply to Muslims, Christians strongly opposed its introduction, for fear that the Sharia law and punishments would be applied to them also. In states where Sharia Law had already been introduced, the sale and consumption of alcohol was prohibited and women were prohibited from traveling with men in public transport vehicles. In Zamfara state where Sharia law was already in effect, amputations and floggings had already been imposed for such things as cattle theft and fornication.[80] The Kaduna branch of the Christian Association of Nigeria (CAN) organized a public protest on February 21.[81] Militant Muslim youths attacked and killed the Christian demonstrators who were protesting the government's plans to implement Sharia Law in Kaduna,

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[79] Simon Robinson, "Even Though Democracy Has Returned to Nigeria, Ethnic Clashes Still Threaten to Cripple the Country," *Time Europe,* February 28, 2000.

[80] Human Rights Watch, "Human Rights in Nigeria: A Briefing for the Visit of President Clinton," *The Extension of Sharia Law,* http://www.hrw.org (accessed February 15, 2009).

[81] Jason Pate, Gary Ackerman, and Kimberly McCloud, 2001, "2000 WMD Terrorism Chronology: Incidents Involving Sub-National Actors and Chemical, Biological, Radiological, or Nuclear Materials," Center for Nonproliferation Studies report, Monterey Institute of International Studies, in Hamid Mohtadi and Antu Murshid, "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005," National Center for Food Protection and Defense, Jul. 7, 2006, 41.

Nigeria. The militants killed some victims with poison arrows, and while the precise number of deaths from the arrows is unknown, at least 300 people died in the violence.[82]

k. 17 March 2000 – Acid – Uganda

On 17 March, reports emerged that 530 members of the Movement for the Restoration of the Ten Commandments of God Sect, burned to death in their church in Kanungu, Uganda.[83] Initially it was not clear whether this was a mass suicide or whether the leader of the cult, Joseph Kibwetere, had lured members to their deaths. Further, police investigation unearthed hundreds of bodies of people who had been poisoned, strangled, and/or stabbed. The final death toll from the fire and the poisonings was 780, the majority from acid poisoning.[84]

l. 19 May 2002 – Poison – Zimbabwe

Seven members of the Johanne Marange Apostolic Church, a Christian fundamentalist group, died, and another 47 were taken ill after drinking tea that had been poisoned

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[82] Jason Pate, Gary Ackerman, and Kimberly McCloud, 2001, "2000 WMD Terrorism Chronology: Incidents Involving Sub-National Actors and Chemical, Biological, Radiological, or Nuclear Materials," Center for Nonproliferation Studies report, Monterey Institute of International Studies.

[83] "160 More Bodies Found at Kanungu," *Africa News Online, The Monitor (Kampala),* March 25, 2000, http://www.rickross.com/reference/tencommandments/tencommandments57.html (accessed February 16, 2009).

[84] Matthias Mugisha, "Kanungu Dead Poisoned," *New Vision (Kampala),* July 28, 2000, http://www.rickross.com/reference/tencommandments/tencommandments108.html (accessed February 16, 2009).

with pesticides. The incident took place near the town of Nyazura, 190 kilometers east of Harare, Zimbabwe.[85]

m. 25 November 2002 — Poison — South Africa

A group of far right-wing whites planned to kill millions of black South Africans by poisoning the water supply of townships near Johannesburg, the South African National Intelligence Agency revealed in 2002. The group also planned to destroy electricity and transport networks serving the same areas, and plotted to detonate bombs made from plastic explosives and other substances in the national parliament building in Cape Town. The plan was to pour Tetranium, an agricultural poison, into several reservoirs in order to reach the approximately ten million victims. However, experts claim that the plot would have failed because of the large amount of chemicals needed.[86]

n. 2002 — Poison — South Africa

A white South African supremacist group, Boeremag, planned to poison black South Africans with poisoned oranges in late 2002. This was part of a larger plan to overthrow the South African government in a coup, which included bombings of Johannesburg's airport and stock exchange and

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[85] Hamid Mohtadi and Antu Murshid, "A Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks: 1950-2005," National Center for Food Protection and Defense, Jul. 7, 2006, 56-57; "Seven Members of a Religious Sect Die After Drinking Tea Suspected to Have Been Poisoned," *Human Rights Without Frontiers*, May 24, 2002, http://www.hrwf.net/religiousfreedom/news/zimbabwe2002.html (accessed February 16, 2009).

[86] Basildon Peta, "Far Right in South Africa Foiled in Plot to Poison Water in Townships," *The Independent: World,* November 25, 2002, http://www.independent.co.uk/news/world/africa/far-right-in-south-africa-foiled-in-plot-to-poison-water-in-townships-605316.html (accessed February 16, 2009).

seizure of radio stations and military bases. It was called off in September 2002, when it became clear the police knew of the plan.[87]

o. September 2002 – Leaking Fuel/Toxic Chemicals – South Africa

In mid-September 2002, a freighter carrying toxic chemicals caught fire off the coast of South Africa and leaked over 1000 tons of fuel onto the coastline. The cargo included 335,000 gallons of fuel oil, 80,000 gallons of gasoline and a variety of toxic chemicals including alpha-naphthylamine, which can be particularly harmful to the environment.[88]

p. September 2002 – Fire/Toxic Chemicals – Nigeria

At least 45 workers died on the night of September 15, 2002, during a fire at a Nigerian plastics factory. The factory, West Africa Rubber Products Limited, owned by a conglomerate based in Shanghai and Hong Kong, was gutted by the fire. Enormous quantities of toxic chemicals were released into the environment due to the fire. The few surviving workers reported that when they tried to escape they found the factory doors locked, and they were trapped. Nigerian papers reported hundreds of deaths as scores of night shift workers remained missing. There were additional

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[87] Michael Wines, "World Briefing | Africa: South Africa: Poison Fruit Plot Described," *The New York Times*, August 12, 2004, http://query.nytimes.com/gst/fullpage.html (accessed February 16, 2009).

[88] "Freighter With Toxic Cargo Spills Fuel on Fragile South African Coast," *Los Angeles Times,* "World," September 14, 2002. http://articles.latimes.com/2002/sep/14/world/fg-oil14 (accessed March 6, 2009).

reports that some of the workers had been fired upon by security guards during their attempts to escape the fire; four were treated with gunshot wounds.[89]

q. March 2003 – Radioactive Material – Nigeria

The International Atomic Energy Agency sent an emergency mission to Nigeria to help find an undisclosed amount of missing or stolen radioactive material. Nigeria asked for help after the material disappeared from an oil company in the southern Niger Delta region.[90]

r. September 2003 – Cyanide Exposure – Tanzania

In September 2003, an epidemic of spastic paraparesis was studied in a drought-affected rural area of Tanzania. A very similar epidemic occurred in 1989 in the same area due to people being forced to subsist on a diet consisting almost exclusively of bitter cassava roots. The drought increased the natural occurrence of cyanogenic glucosides in the roots, and the procedure to remove the cyanide before consumption was shortened thanks to the people's hunger. Similar outbreaks occurred in Mozambique and Zaire, where the disease was reported under the name

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[89] World Socialist Web Site, "Nigerian Factory Fire Kills 45 Workers," September 25, 2002, https://wsws.org/articles/2002/sep2002/fire-s25.shtml (accessed March 6, 2009).

[90] "U.N. Agency Hunting for Radioactive Material," *Los Angeles Times,* "World," March 1, 2003, http://articles.latimes.com/2003/mar/01/world/fg-briefs1.3 (accessed March 6, 2009); B. Olowokure and others, "Global Surveillance for Chemical Incidents of International Public Health Concern," Bulletin of the World Health Organization 83, no. 12, (2005): 930.

"konzo." The poisoning affects upper motor neurons and causes permanent paralysis in the sufferer's legs.[91]

[91] W.P. Howlett and others, "Konzo, an Epidemic Upper Motor Neuron Disease Studied in Tanzania," *Brain: A Journal of Neurology* 113, no. 1 (1990): 223-235.

APPENDIX B

Below is a sample list of major resources found in Africa and the associated environmental concerns for each country that the Chemical Corps has the ability, or could develop the ability, to help ameliorate.[92]

- **Algeria**: petroleum, natural gas, iron ore, phosphates, uranium, lead, zinc

  Issues: soil erosion from overgrazing and other poor farming practices; desertification; dumping of raw sewage, petroleum refining wastes, and other industrial effluents are leading to the pollution of rivers and coastal waters; the Mediterranean Sea, in particular, is becoming polluted from oil wastes, soil erosion, and fertilizer runoff; inadequate supplies of potable water

- **Angola**: petroleum, diamonds, iron ore, phosphates, copper, feldspar, gold, bauxite, uranium

  Issues: overuse of pastures and subsequent soil erosion attributable to population pressures; desertification; deforestation of tropical rain forest, in response to both international demand for tropical timber and domestic use as fuel, resulting in loss of biodiversity; soil erosion contributing to water pollution and siltation of rivers and dams; inadequate supplies of potable water

- **Benin**: small offshore oil deposits, limestone, marble, timber

  Issues: inadequate supplies of potable water; poaching threatens wildlife populations; deforestation; desertification

[92] CIA, *The World Factbook* (2009), https://cia.gov/library/publications/the-world-factbook/geos/bn.html#Geo (accessed March 14, 2009).

- **Botswana**: diamonds, copper, nickel, salt, soda ash, potash, coal, iron ore, silver

  Issues: overgrazing; desertification; limited fresh water resources

- **Burkina Faso:** manganese, limestone, marble; small deposits of gold, phosphates, pumice, salt

  Issues: recent droughts and desertification are severely affecting agricultural activities, population distribution, and the economy; overgrazing; soil degradation; deforestation

- **Burundi:** nickel, uranium, rare earth oxides, peat, cobalt, copper, platinum, vanadium, arable land, hydropower, niobium, tantalum, gold, tin, tungsten, kaolin, limestone

  Issues: flooding; landslides; drought; soil erosion as a result of overgrazing and the expansion of agriculture onto marginal lands; deforestation (little forested land remains because of uncontrolled cutting of trees for fuel); habitat loss threatens wildlife populations

- **Cameroon**: petroleum, bauxite, iron ore, timber, hydropower

  Issues: waterborne diseases are prevalent; deforestation; overgrazing; desertification; poaching; overfishing

- **Cape Verde:** salt, basalt rock, limestone, kaolin, fish, clay, gypsum

  Issues: prolonged droughts; seasonal harmattan wind produces obscuring dust; volcanically and seismic activity; soil erosion; deforestation due to demand for wood used as fuel; water shortages; desertification; environmental damage threatens several species of birds and reptiles; illegal beach sand extraction; overfishing

- **Central African Republic**: diamonds, uranium, timber, gold, oil, hydropower

  Issues: tap water is not potable; poaching has diminished the country's reputation as one of the last great wildlife refuges; desertification; deforestation

- **Chad:** petroleum, uranium, natron, kaolin, fish (Lake Chad), gold, limestone, sand and gravel, salt

  Issues: periodic droughts; locust plagues; inadequate supplies of potable water; improper waste disposal in rural areas contributes to soil and water pollution; desertification

- **Comoros:** negligible

  Issues: cyclones possible during rainy season (December to April); Le Karthala on Grand Comore is an active volcano; soil degradation and erosion results from crop cultivation on slopes without proper terracing; deforestation

- **Congo, Democratic Republic of the**: cobalt, copper, niobium, tantalum, petroleum, industrial and gem diamonds, gold, silver, zinc, manganese, tin, uranium, coal, hydropower, timber

  Issues: periodic droughts in the south; Congo River floods (seasonal); active volcanoes in the Great Rift Valley in the east; poaching threatens wildlife populations; water pollution; deforestation; refugees responsible for significant deforestation, soil erosion; mining of minerals (coltan - a mineral used in creating capacitors, diamonds, and gold) is causing environmental damage

- **Congo, Republic of the (Zaire)**: petroleum, timber, potash, lead, zinc, uranium, copper, phosphates, gold, magnesium, natural gas, hydropower

  Issues: seasonal flooding; air pollution from vehicle emissions; water pollution from the dumping of raw sewage; tap water is not potable; deforestation

- **Cote d'Ivoire**: petroleum, natural gas, diamonds, manganese, iron ore, cobalt, bauxite, copper, gold, nickel, tantalum, silica sand, clay, cocoa beans, coffee, palm oil, hydropower

  Issues: during the rainy season torrential flooding is possible; deforestation (most of the country's forests, once the largest in West

Africa, have been heavily logged); water pollution from sewage and industrial and agricultural effluents

- **Djibouti**: geothermal areas, gold, clay, granite, limestone, marble, salt, diatomite, gypsum, pumice, petroleum

  Issues: earthquakes; droughts; occasional cyclonic disturbances from the Indian Ocean bring heavy rains and flash floods; inadequate supplies of potable water; limited arable land; desertification; endangered species

- **Egypt**: Currently, Egypt is still considered to be part of CENTCOM's Area of Focus due to the similarities between the people and cultures, it is not part of AFRICOM.

- **Equatorial Guinea**: petroleum, natural gas, timber, gold, bauxite, diamonds, tantalum, sand and gravel, clay

  Issues: violent windstorms; flash floods; tap water is not potable; deforestation

- **Eritrea:** gold, potash, zinc, copper, salt, possibly oil and natural gas, fish

  Issues: frequent droughts; locust swarms; deforestation; desertification; soil erosion; overgrazing; loss of infrastructure from civil warfare

- **Ethiopia:** small reserves of gold, platinum, copper, potash, natural gas, hydropower

  Issues: geologically active Great Rift Valley susceptible to earthquakes, volcanic eruptions; frequent droughts; deforestation; overgrazing; soil erosion; desertification; water shortages in some areas from water-intensive farming and poor management

- **Gabon:** petroleum, natural gas, diamond, niobium, manganese, uranium, gold, timber, iron ore, hydropower

  Issues: deforestation; poaching

- **Gambia, The**: fish, titanium (rutile and ilmenite), tin, zircon, silica sand, clay, petroleum

  Issues: drought (rainfall has dropped by 30% in the last 30 years); deforestation; desertification; water-borne diseases prevalent

- **Ghana:** gold, timber, industrial diamonds, bauxite, manganese, fish, rubber, hydropower, petroleum, silver, salt, limestone

  Issues: recurrent drought in north severely affects agricultural activities; deforestation; overgrazing; soil erosion; poaching and habitat destruction threatens wildlife populations; water pollution; inadequate supplies of potable water

- **Guinea:** bauxite, iron ore, diamonds, gold, uranium, hydropower, fish, salt

  Issues: deforestation; inadequate supplies of potable water; desertification; soil contamination and erosion; overfishing, overpopulation in forest region; poor mining practices have led to environmental damage

- **Guinea Bissau**: fish, timber, phosphates, bauxite, clay, granite, limestone, unexploited deposits of petroleum

  Issues: brush fires; deforestation; soil erosion; overgrazing; overfishing

- **Kenya:** limestone, soda ash, salt, gemstones, fluorspar, zinc, diatomite, gypsum, wildlife, hydropower

  Issues: recurring drought; flooding during rainy seasons; water pollution from urban and industrial wastes; degradation of water quality from increased use of pesticides and fertilizers; water hyacinth infestation in Lake Victoria; deforestation; soil erosion; desertification; poaching

- **Lesotho**: water, agricultural and grazing land, diamonds, sand, clay, building stone

  Issues: periodic droughts; population pressure is forcing settlement in marginal areas resulting in overgrazing, severe soil erosion, and soil

exhaustion; desertification; Highlands Water Project controls, stores, and redirects water to South Africa

- **Liberia:** iron ore, timber, diamonds, gold, hydropower

  Issues: tropical rain forest deforestation; soil erosion; loss of biodiversity; pollution of coastal waters from oil residue and raw sewage

- **Libya:** petroleum, natural gas, gypsum

  Issues: dust storms; sand storms; desertification; limited natural fresh water resources; the Great Manmade River Project, the largest water development scheme in the world, is being built to bring water from large aquifers under the Sahara to coastal cities

- **Madagascar:** graphite, chromite, coal, bauxite, salt, quartz, tar sands, semiprecious stones, mica, fish, hydropower

  Issues: periodic cyclones, drought, and locust infestations; soil erosion results from deforestation and overgrazing; desertification; surface water contaminated with raw sewage and other organic wastes; several endangered species of flora and fauna unique to the island

- **Malawi:** limestone, arable land, hydropower, unexploited deposits of uranium, coal, and bauxite

  Issues: deforestation; land degradation; water pollution from agricultural runoff, sewage, industrial wastes; siltation of spawning grounds endangers fish populations (Lake Malawi)

- **Mali:** gold, phosphates, kaolin, salt, limestone, uranium, gypsum, granite, hydropower *note:* bauxite, iron ore, manganese, tin, and copper deposits are known but not exploited

  Issues: recurring droughts; occasional Niger River flooding; deforestation; soil erosion; desertification; inadequate supplies of potable water; poaching

- **Mauritania:** iron ore, gypsum, copper, phosphate, diamonds, gold, oil, fish

  Issues: periodic droughts; overgrazing, deforestation, and soil erosion aggravated by drought are contributing to desertification; limited natural fresh water resources away from the Senegal, which is the only perennial river; locust infestations

- **Mauritius:** arable land, fish

  Issues: cyclones; water pollution, degradation of coral reefs

- **Morocco:** phosphates, iron ore, manganese, lead, zinc, fish, salt

  Issues: northern mountains geologically unstable and subject to earthquakes; periodic droughts; land degradation/desertification (soil erosion resulting from farming of marginal areas, overgrazing, destruction of vegetation); water supplies contaminated by raw sewage; siltation of reservoirs; oil pollution of coastal waters

- **Mozambique:** coal, titanium, natural gas, hydropower, tantalum, graphite

  Issues: severe droughts; devastating cyclones and floods in central and southern provinces; a long civil war and recurrent drought in the hinterlands have resulted in increased migration of the population to urban and coastal areas with adverse environmental consequences; desertification; pollution of surface and coastal waters; poaching of elephants for ivory

- **Namibia:** diamonds, copper, uranium, gold, silver, lead, tin, lithium, cadmium, tungsten, zinc, salt, hydropower, fish *note:* suspected deposits of oil, coal, and iron ore

  Issues: prolonged periods of drought; limited natural fresh water resources; desertification; wildlife poaching; land degradation has led to pressure on conservation areas

- **Niger:** uranium, coal, iron ore, tin, phosphates, gold, molybdenum, gypsum, salt, petroleum

  Issues: recurring droughts; overgrazing; soil erosion; deforestation; desertification; wildlife populations (such as elephant, hippopotamus, giraffe, and lion) threatened because of poaching and habitat destruction

- **Nigeria:** natural gas, petroleum, tin, iron ore, coal, limestone, niobium, lead, zinc, arable land

  Issues: periodic droughts; flooding; soil degradation; rapid deforestation; urban air and water pollution; desertification; oil pollution - water, air, and soil; has suffered serious damage from oil spills; loss of arable land; rapid urbanization

- **Rwanda:** gold, cassiterite (tin ore), wolframite (tungsten ore), methane, hydropower, arable land

  Issues: periodic droughts; volcanic activity in the Virunga mountains along the border with the Democratic Republic of the Congo; deforestation results from uncontrolled cutting of trees for fuel; overgrazing; soil exhaustion; soil erosion; widespread poaching

- **Sao Tome and Principe:** fish, hydropower

  Issues: deforestation; soil erosion and exhaustion

- **Senegal:** fish, phosphates, iron ore

  Issues: lowlands seasonally flooded; periodic droughts; wildlife populations threatened by poaching; deforestation; overgrazing; soil erosion; desertification; overfishing

- **Seychelles:** fish, copra, cinnamon trees

  Issues: short droughts possible; water supply depends on catchments to collect rainwater

- **Sierra Leone:** diamonds, titanium ore, bauxite, iron ore, gold, chromite

  Issues: sandstorms, dust storms; rapid population growth pressuring the environment; overharvesting of timber, expansion of cattle grazing, and slash-and-burn agriculture have resulted in

deforestation and soil exhaustion; civil war has depleted natural resources; overfishing

- **Somalia:** uranium and largely unexploited reserves of iron ore, tin, gypsum, bauxite, copper, salt, natural gas, likely oil reserves

  Issues: recurring droughts; frequent dust storms over eastern plains in summer; floods during rainy season; famine; use of contaminated water contributes to human health problems; deforestation; overgrazing; soil erosion; desertification

- **South Africa:** gold, chromium, antimony, coal, iron ore, manganese, nickel, phosphates, tin, uranium, gem diamonds, platinum, copper, vanadium, salt, natural gas

  Issues: prolonged droughts; lack of important arterial rivers or lakes requires extensive water conservation and control measures; growth in water usage is outpacing supply; pollution of rivers from agricultural runoff and urban discharge; air pollution resulting in acid rain; soil erosion; desertification

- **Sudan:** petroleum; small reserves of iron ore, copper, chromium ore, zinc, tungsten, mica, silver, gold, hydropower

  Issues: dust storms and periodic persistent droughts; inadequate supplies of potable water; wildlife populations threatened by excessive hunting; soil erosion; desertification

- **Swaziland:** asbestos, coal, clay, cassiterite, hydropower, forests, small gold and diamond deposits, quarry stone, and talc

  Issues: drought; limited supplies of potable water; wildlife populations being depleted because of excessive hunting; overgrazing; soil degradation; soil erosion

- **Tanzania:** hydropower, tin, phosphates, iron ore, coal, diamonds, gemstones, gold, natural gas, nickel

  Issues: flooding on the central plateau during the rainy season; drought; soil degradation;

deforestation; desertification; destruction of coral reefs threatens marine habitats; recent droughts are affecting marginal agriculture; wildlife is threatened by illegal hunting and trade, especially for ivory

- **Togo:** phosphates, limestone, marble, arable land

  Issues: periodic droughts; deforestation attributable to slash-and-burn agriculture and the use of wood for fuel; water pollution presents health hazards and hinders the fishing industry; air pollution is increasing in urban areas

- **Tunisia:** petroleum, phosphates, iron ore, lead, zinc, salt

  Issues: toxic and hazardous waste disposal are ineffective and pose health risks; water pollution from raw sewage; limited natural fresh water resources; deforestation; overgrazing; soil erosion; desertification

- **Uganda:** copper, cobalt, hydropower, limestone, salt, arable land

  Issues: draining of wetlands for agricultural use; deforestation; overgrazing; soil erosion; water hyacinth infestation in Lake Victoria; widespread poaching

- **Western Sahara:** phosphates, iron ore

  Issues: hot, dry, dust/sand-laden sirocco wind can occur during winter and spring; widespread harmattan haze exists 60% of time, often severely restricting visibility; sparse water and lack of arable land

- **Zambia:** copper, cobalt, zinc, lead, coal, emeralds, gold, silver, uranium, hydropower

  Issues: periodic drought, tropical storms; air pollution and resulting acid rain in the mineral extraction and refining region; chemical runoff into watersheds; poaching seriously threatens rhinoceros, elephant, antelope, and large cat populations; deforestation; soil erosion; desertification; lack of adequate water treatment presents human health risks

- **Zimbabwe:** coal, chromium ore, asbestos, gold, nickel, copper, iron ore, vanadium, lithium, tin, platinum group metals

  Issues: recurring droughts; deforestation; soil erosion; land degradation; air and water pollution; the black rhinoceros herd—once the largest concentration of the species in the world—has been significantly reduced by poaching; poor mining practices have led to toxic waste and heavy metal pollution

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