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7. Korea-Wide Environmental Baseline Surveys. Korea-wide environmental baseline surveys, if they exist, are not available for USFK review. Interviewees felt that numerous hazardous waste sites probably exist throughout the country as a result of poor environmental practices during the Japanese occupation and the Korean War. Some of the sites probably exist on DoD installations, or contamination from off-installation sites may have migrated onto DoD installations over the past 44 years since the end of the war. Locating and tracing sources of such contamination would be virtually impossible, especially for unrecoverable contaminants such as DNAPLs. Bases which served as operating sites for the Japanese military prior to the Korean War, such as Kunsan Air Base, may also contain residual contamination. Once again, pinpointing the source and liable party for such contamination would be extremely difficult at best (27).

8. Contamination Outside Installation Boundaries. At many DoD installations, land ceded for USFK use lies outside the physical barriers (perimeter fence line). Some training ranges, such as the MPRC in Tongduchon, do not have perimeter fencing at all, allowing free access onto property for which DoD has primary responsibility for environmental protection (181). As in the preceding finding, determination of liability for contamination on free access property would be infeasible since anyone, including Korean civilians, could presumably contaminate soil and/or groundwater without DoD knowledge (27; 83; 181).

b. Air Force-Unique Findings.

1. High Turn-Over Rate. Personnel at both Air Force bases felt strongly that the high turn-over rate of personnel was a major hindrance to effective management of the

environmental program as a whole, and the restoration problem in particular. Nearly all military personnel at Kunsan and Osan Air Bases serve a one-year tour of duty with the exception of a select handful of individuals at Osan. Interviewees complained of the "shortsightedness" associated with a one-year assignment, which inevitably leads to lowering the priority of long-term projects such as remediation of contaminated sites. According to base-level personnel, corporate knowledge is also a victim of the high turn-over rate. Information on spill sites, leaking fuel tanks, and other contaminant sources—written or otherwise—eventually becomes "lost" over the years, only to surface accidentally during construction projects or as contaminants eventually leach to the surface and enter the ground water. Inception of long-term strategic plans, such as management action plans or strategic environmental plans may solve the problem of lost corporate knowledge. The Directorate of The Civil Engineer at Headquarters PACAF recently engaged the 240th Civil Engineer Flight, Buckley Air National Guard Base, to accomplish a restoration management action plan for Osan Air Base, and Kunsan Air Base contracted with Woodward-Clyde Federal Services and AFCEE to complete a strategic environmental plan for their installation. Both documents represent an important step by decision-makers to quantify requirements and devise a long-term solution to restoration problems at the respective bases. Execution is the next step, which the high turn-over rate may hinder. At the time of the site visit in June 1997, Kunsan's environmental staff had not reviewed the first draft of the Kunsan strategic environmental plan, which was completed by AFCEE in April 1997 (7).

2. Contamination Caused By ROK Air Force/Army Units on DoD Installations. Interviewees believed poor environmental stewardship practiced by the ROK Air Force (ROKAF) and ROK Army (ROKA) tenant units on Kunsan Air Base, Osan Air Base, and the COBs may be a significant cause of hazardous waste sites at those installations. However, since the ROKAF/ROKA do not allow U.S. military personnel within their compounds, base personnel could not provide conclusive evidence of ROKAF/ROKA-created hazardous waste sites. The only indication of possible environmental mismanagement was found at Kunsan Air Base, where engineers discovered oil and grease flowing from a ROKAF dining facility into a storm water drainage ditch, and experienced several cases of illegal municipal solid waste dumping. The ROKAF unit also discharges raw domestic sewage directly into base stormwater drainage ditches, which eventually empty into the Yellow Sea. One interviewee mentioned that ROKAF/ROKA hazardous materials circumvent the base's central hazardous material distribution system. Consequently, DoD personnel are unaware of the quantities and types of hazardous materials used and disposed of by ROKAF/ROKA personnel. (7; 8; 72; 171; 173).

c. Army-Unique Findings

1. Manning. Personnel at two of the three Army installations visited complained of the minimal manning levels in the environmental staff office. Interviewees stated that the authorized manning level (one individual at Camp Carroll, and five personnel at Camp Casey) was insufficient to adequately accomplish all environmental tasks. Of the four primary areas within the environmental program (cleanup, compliance, conservation,

and pollution prevention), cleanup is the one program that does not receive equal attention since: (1) remediation of contaminated sites, other than those representing an imminent and substantial endangerment to human health, is not a requirement and, (2) cleanup must be funded from existing operations and maintenance or compliance funds, which other mission priorities normally override.

2. Project Prioritization System. The project prioritization system for Army installations does not allow direct input from installation environmental personnel. Requests for environmental project funding from all installations on the peninsula are funneled to the 19th TAACOM for review, prioritization, and funding with nothing more than the information submitted via the A-106 environmental project documentation system. 19th TAACOM periodically conducts project prioritization meetings where installation commanders may provide additional justification and data to support funding for their projects. Ultimately, however, individuals with little knowledge of installation-specific environmental conditions compare and eventually rank projects from 83 installations with varying missions (ground forces, aviation, troop support, logistics, and depot-level maintenance) without benefit of direct input from environmental experts.

d. Installation-Unique Findings

(1) Kunsan Air Base.

1. Haje Village Landfill. In the Fall of 1996, installation personnel discovered domestic waste illegally placed near the base fence line adjacent to Haje Village, a small civilian community of approximately 1,500 people. The waste, consisting of drywall, spray cans, trash, office furniture, scrap metal, and other domestic products, appeared to

be recently emplaced by the Haje Village locals. The Korea FGS specifically prohibits surface waste disposal (165:7-11). Base engineers removed seven, 10-ton truck loads of waste from the area in January 1997, destroying the "ramp" of trash which actually allowed access to the base over the existing fence line. Bi-monthly site visits since removing the trash indicate no unusual odors, stained soils, or stressed vegetation, although base personnel took no soil samples. The area surrounding the surface dump site was a former base landfill. While no records indicate that hazardous materials were disposed at the site, samples to confirm historical records were never taken. Kunsan's environmental staff also mentioned that the area serves as a "temporary" site for land farming of petroleum contaminated soil. The land farm area, however, contains no leachate collection system, or other secondary containment system. Base personnel also observed a pipe from an off-base source emptying into the base's storm water run-off in the same area. Discharge from the pipe is unknown; however, engineers believe the effluent consists of agricultural run-off fertilized with night soil (typically high nitrate concentrations) (8; 171).

2. Dumping of Construction Debris in the Yellow Sea. In December 1996, Woo Jung Construction Company, contracted by Kunsan Air Base, disposed of concrete debris from demolition of ten facilities on "South Beach" (area of coastline near the south end of the airfield). The local community publicized the incident as a violation of Korean environmental law, raising public pressure to remove the debris. According to interviewees, the demolition contractor asked and received permission from the base contracting office to dump concrete debris on South Beach. The key environmental law

in question was the Korean Waste Management Law, which requires an "approved contractor" to dispose of construction debris. Paragraph 7-3q of the FGS states:

> "No one shall dump any waste in . . . public beaches. . . harbors . . . without justifiable reasons. Other areas prohibited from open waste dumping are defined as . . . coastal areas." (165:7-3)

Engineers requested base and USFK legal officials for their opinion on the matter. Interviewees did not provide information on the final legal determination; however, as of 18 June 1997, the debris remains on South Beach (8; 171).

3. Automotive Battery "Graveyard". One of the environmental staff located what appeared to be landfilled batteries adjacent to a ROK Army gun emplacement. Although the batteries "disappeared" one day after speaking with ROKA officials, no soil sampling has been accomplished to date, despite the area's proximity to a storm water drainage ditch (which flows into the Yellow Sea) and off-base rice paddies (171).

4. Stormwater Drainage Ditches. The base bioenvironmental engineer identified storm water drainage ditches, fed by numerous non-point sources, as likely hazardous waste sites. Sludge, probably containing POL products, solvents, and/or heavy metals, have accumulated in ditches throughout base. However, no sample results exist to conclusively verify findings. The bioenvironmental engineer admitted that sampling of sediments in storm water drainage ditches, especially at areas adjacent to the base boundary, should be accomplished immediately to avoid possible violation of Korean environmental law (71).

5. Landfarm Maintenance. The base recently completed construction of a landfarm facility to remediate contaminated soils. However, the entire project, from design through construction, was not coordinated with bioenvironmental engineering. Consequently, bioenvironmental engineering did not budget funds for periodic sampling of landfarmed soil and the area surrounding the facility—requirements to ensure the landfarm operates properly and contaminants do not leach into the surrounding subsurface (71).

(2) Osan Air Base.

1. Well Sampling At Collocated Operating Bases. The bioenvironmental engineer accomplished water sampling of all groundwater wells at the COBs in early 1997; however, he said results could not be released for this thesis due to "security considerations." Nevertheless, he did confirm that sample results at Osan indicated that several contingency wells were contaminated with POL products and chlorinated solvents (9).

2. Landfarm. A landfarm facility exists at Osan for remediation of POL-contaminated soil, which may be a potential hazardous waste site. Engineers place six- to eight-inches of contaminated soil over a subsurface consisting of gravel, sand, and clay (no geomembrane or other liner system is used), provide water and surfactant, and periodically turn the soil to enhance aerobic degradation of POL products. However, bioenvironmental engineering does not sample the soil to ensure complete degradation or possible migration of contaminants below the landfarm facility. The only method of testing is a "sniff test" (9).

(3) Camp Carroll.

1. Groundwater Contamination. The installation environmental officer verified contamination of seven drinking water wells on Camp Carroll. He mentioned that aeration towers had been installed to treat the contaminated water, and an additional tower is slated for construction in the future. Despite the existence of these towers, the seven wells remain inactive pending further investigation into the source of contamination (trichloroethylene) and direction of groundwater flow. The location of several wells, near the installation boundary, has raised concern over possible contamination emanating from the installation to off-base receptors (83).

2. Logistics Center. Two sites, one contaminated with malathion, and the other with trichloroethylene and 1,1 dichloroethylene, exist within the Material Support Center compound on Camp Carroll. Both areas have been fenced and are likely candidates for remediation in the future, if funding can be secured from 19th TAACOM (83).

(4) Camp Casey.

1. Groundwater Contamination. Two of 23 groundwater wells have been abandoned due to POL contamination. The wells provide approximately 25 percent of the drinking water for Camp Casey—16 percent comes from commercial (city) sources; 59 percent originates from a surface source (creek). According to the environmental engineer interviewed, the aquifer feeding the contaminated wells has never been investigated for possible remediation (181).

2. Surface Water Contamination. The Shinchon waterway, which supplies a portion of Camp Casey's potable water supply and serves as the primary source of

drinking water for the city of Tongduchon, has been the subject of recent public scrutiny. An article appeared in the local newspaper during the site visit to Camp Casey which alleged that water downstream from Camp Casey's sewage outfall point "looked" worse than at points above the outfall. In the article, city officials urged the installation to meet Korean environmental law. However, according to Camp Casey's environmental engineer, effluent from the sewage plant (which provides secondary treatment) is well below the Korean standard of less than 60 ppm BOD_5 (5-day biodegradable oxygen demand test), and the total suspended solids limits (the Korea FGS also mandates this standard for Camp Casey) (181).

(5) Camp Market.

POL Contaminated Site and Battery "Graveyard." The head of the Defense, Reutilization and Marketing Office's (DRMO's) environmental branch at Camp Market discussed POL contamination throughout the vehicle storage and disassembly yard. He provided documentation concerning a Corps of Engineers study accomplished in 1992 (152). In accordance with conclusions of the 1992 study, he believed in-depth investigation is still required at the POL-contaminated site and has submitted a project to 19th TAACOM. The environmental branch chief also mentioned a suspected vehicle battery landfill located adjacent to the vehicle disassembly yard. During installation of communication cables, contractors uncovered a number of lead-acid batteries. In most cases, the contents of the batteries had leaked through punctured cases. The interviewee believed that the soil is probably contaminated with lead; however, further investigation has never been accomplished at this area.

C. Field Observations

1. General.

As surmised in Chapter 2 (Methodology), many of the physical characteristics associated with hazardous waste sites cannot be readily observed without meticulous sampling and analysis techniques. Researchers spent the majority of their time during site visits interviewing personnel and collecting various types of documentation including results from previous studies and site characterizations, periodic sampling results required by DoD and USFK regulations, updates to Korean environmental law and policy, Korean environmental documents unavailable in the United States, compliance assessment results (ECAS and ECAMP reports), and official DoD correspondence.

However, a few obvious characteristics of hazardous waste sites, such as distressed vegetation, distinctive odors (POL), floating petroleum products, and oil-stained soil, are observable. Inferences can also be made about possible receptors and exposure pathways for contaminants at specific sites. Researchers focused on these readily discernible facets of hazardous waste sites during site visits in Korea.

2. Observations.

Personnel from the environmental offices provided tours of known/suspected hazardous waste sites at all installations visited. Consequently, some findings from the literature review and personal interviews were validated when contamination was observed on the ground surface. Highlights of these findings follow.

1. Municipal Solid Waste Collection Points. Numerous municipal solid waste (MSW) collection points, usually consisting of a simple concrete pad surrounded on all

sides by a short (approximately three-foot-high) concrete masonry block wall, exist on all installations visited. With very few exceptions, these collection points are not covered, and those with roofs are still open on all sides (from the top of the wall to the roof structure). The floors of a few collection points were heavily stained with what appeared to be used oil.

2. Landfarm Facility at Osan. The landfarm facility at Osan Air Base is located in close proximity to the base boundary, immediately across a two-lane road, and perched on a built-up area approximately twenty feet about ground level. Adjacent to the fence line is an irrigation ditch feeding rice fields. When touring the site, base personnel pointed out cracks in the landfarm holding pit. The pit is used to temporarily store contaminated soil while the landfarm turning bed is in use. When they noticed the cracks, the environmental staff immediately stopped accepting contaminated soil, at least until the cracks are repaired. There appears to be no plan, however, to sample soil beneath the holding pit even though no one could estimate how long the cracks had existed prior to their discovery. Interviewees did not believe that the facility's distance from the perimeter fence nor elevation presented a risk to off-base receptors should the landfarm containment system fail, or should runoff from heavy rain events enter the off-base irrigation ditch.

3. Manning Levels. Environmental staff offices at Army installations appeared undermanned given their scope of responsibilities. For example, Camp Carroll, which conducts depot-level maintenance for EUSA's entire general purpose vehicle, heavy equipment, and combat vehicle fleet and houses the Army's Material Support Center (the

largest DoD logistics complex in Korea), has one person to manage the installation's environmental program, which includes hazardous waste management, compliance, pollution prevention, cultural and natural resources, and cleanup. In comparison, Kunsan Air Base, which has a comparable amount of facility square footage, has seven personnel assigned to the base environmental function. Camp Casey, with 27 percent more acreage and 10 percent more facility square footage, has only five personnel assigned. Camp Casey's environmental office is also responsible for 4 additional installations, so that the total acreage and facility square footage that Camp Casey environmental personnel are responsible for overseeing are 66 percent and 57 percent, respectively, greater than Kunsan Air Base.

4. Environmental Programs Office, Headquarters USFK/EUSA. The focus of EPO's efforts seemed firmly aimed toward Army organizations. Little or no information on Air Force and Navy environmental programs is kept by EPO—for example, EPO does not maintain ECAMP reports for any of the Air Force bases and COBs, nor do any USFK personnel participate in external ECAMP audits. They only appeared to interface with the other services in select areas:

a. The hazardous waste management program (coordinating transportation requirements and disposal quantities with DRMO, and finding solutions for unique waste problems)

b. Problems which have captured local community attention, such as the wastewater treatment problems at Osan Air Base and Camp Casey

c. Coordination of peninsula-wide policy, such as the Korea FGS and the soon-to-be-released USFK remediation policy.

V. ANALYSIS

A. Overview

Chapters 3 and 4 presented various issues influencing hazardous waste site remediation policy in Korea from three differing perspectives—top-level DoD decision-makers, the Korean community, and the installation environmental managers, gathered using three different data collection methods—literature review, personal interviews, and field observations. These findings will now be analyzed using the triangulation methodology presented in Chapter 2 to reach the primary objective of this research—namely, to further the understanding of hazardous waste site remediation issues in Korea. A summary of the findings can be found in Appendix 5-1.

B. Background

The goal of this thesis was to gather information for use by DoD policy makers when crafting hazardous waste site remediation policy for installations in Korea. As discussed in Chapter 2, triangulation was chosen as the methodological basis for uncovering issues relevant to DoD hazardous waste site remediation policy for Korea and analyzing findings from each of the single methodologies employed—literature review, personal interviews, and field observations. Employment of each research method furnished information from various organizations within the DoD and ROK, as well as from independent academic journal articles. Findings were compared in two ways:

1. Within each method, findings from the various groups were compared for qualitative convergence. For example, perceptions concerning the state of ROK environmental awareness received from DUSD(ES), USFK, MND, and MOE were

compared to determine if convergence of perceptions occurred among the various data sources.

2. Within each group, findings furnished through the different methodologies were also compared. Taking the same example in the previous paragraph, data gathered from the personal interview with MOE concerning the level of ROK environmental awareness were compared with information from ROK government publications and academic journals.

Hence, both "within-method" and "between-method" triangulation was used to cross-check findings for internal consistency and provide external validity to the findings, respectively. Figure 6 pictorially illustrates these comparisons.

However, before attempting to compare findings, a return to the thesis goal is in order. Establishing the goal rested on a key assumption—namely, that remediation policy for Korea should consider all issues—political, legal, economic, diplomatic, technological, security, and environmental/health—relevant to cleanup of hazardous waste sites on DoD installations in Korea. Chapter 1 of the thesis articulated these issues as:

1. Compliance with U.S. and ROK environmental law and international agreements between both countries. At a minimum, DoD remediation policy in Korea must comply with the rules and regulations established by Congress. Similarly, DoD organizations must operate within the confines of agreements made with the host nation. In the case of Korea, meeting the provisions of both U.S. law and applicable international agreements entail compliance with ROK environmental law to some degree.

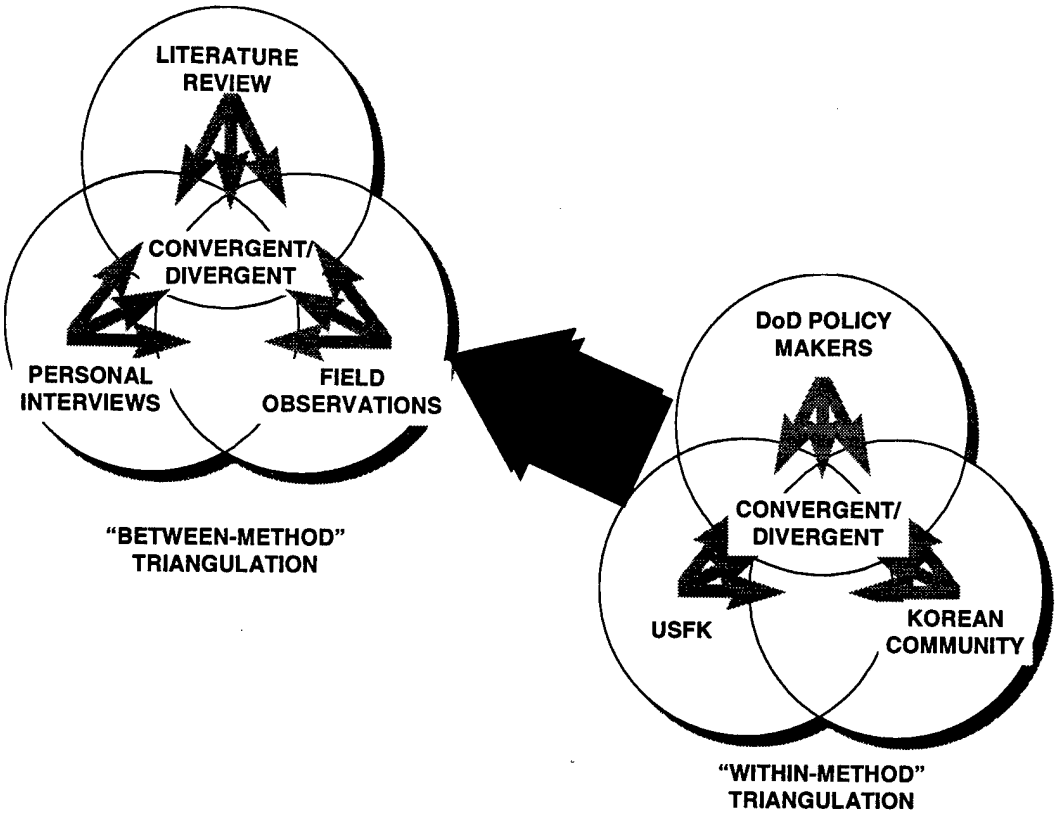

Figure 6: "Between-Method" and "Within-Method" Triangulation

In accordance with DODI 4715.5 and 4715.8, USFK is responsible for identifying applicable Korean environmental laws, determining the degree to which those laws apply, and translating requirements for all DoD organizations in Korea via the FGS.

2. Fulfillment of DoD environmental policy makers' fundamental objectives. For purposes of this study, these policy makers include the Deputy Undersecretary of Defense for Environmental Security, who provides the overarching remediation policy for all DoD activities overseas, and United States Forces Korea—the DoD environmental executive agent charged with defining remediation policy specifically for the Korean theater. After analyzing the data from personal interviews and literature, it became clear that these two

groups of policy makers had somewhat different objectives in establishing remediation policy.

3. Cleanup precedents established in other foreign countries. Clearly, DoD policy must comply with U.S. law and international agreements. Only after personal interviews were completed was the relevancy of historical precedents in other countries established.

4. Extent of soil and groundwater contamination on DoD installations in Korea, and its effect on peacetime operations and warfighting capability. The accessibility of areas critical to maintaining a mission-ready military presence in Korea, and to operating in a contingency environment depends upon the health of the environment. Depending upon the risk they present to human health, hazardous waste sites may conceivably block access to vital areas of operation, or render certain important resources (such as groundwater) unusable. In addition to the direct relationship between contaminated sites and availability of warfighting resources, indirect relationships between the extent of contamination and peacetime/wartime operations also surfaced:

a. Remediation policy determines the number of sites (by specifying the level of contaminant or human health risk to be considered "safe") and degree of remediation necessary to consider remediated sites "cleaned" (by establishing contaminant concentration-based or risk-based threshold values). This, in turn, influences the funds necessary to meet policy objectives. The funds needed to fulfill remediation policy objectives affect the ability to conduct peacetime operations, since funds for cleanup currently come from installation operations and maintenance or environmental compliance accounts. The former appropriation also pays for mission-

support functions, such as maintenance and repair of infrastructure (facilities, utility systems, airfield pavements, and base pavements), utilities, supplies (including aircraft parts), and fuel. The latter appropriation is primarily used to ensure compliance with U.S. law and, in overseas locations, the country-specific FGS. While availability of funds should not inhibit a commander's ability to safeguard the health of his/her organization, the current remediation funding scheme forces commanders to compare and prioritize remediation requirements alongside mission requirements. Policy extremely protective of human health may impact mission-support functions due to finite resources and competing requirements; weak policy may not adequately protect human health and safety in peacetime and contingencies.

b. The Korean government general public clearly scrutinize DoD operations to determine their effect on the Korean environment. To date, their scrutiny has been limited to studying the possibility of contamination emanating *from* DoD installations (which has an obvious impact on the welfare of Korean citizens). However, the ROK government continues to press USFK for access onto U.S. installations in order to assess contamination *on* DoD installations, since the land area will inevitably revert to Korean use at some point in the future. Remediation policy directly affects the extent of contamination on and emanating from DoD installations in that it determines cleanup action levels and scope of DoD responsibility. In turn, the extent of contamination influences Korean perception of DoD environmental stewardship, which, in the long run, affects DoD's ability to maintain access to Korean land for its peacetime and contingency operations. Furthermore, DoD policy of prohibiting joint environmental assessments

coupled with USFK policy of refusing to release the FGS and information concerning the "health" of its installations to Korean officials have aroused suspicion among the Korean populace with regard to DoD's stewardship. Such suspicion may result in mounting public pressure to evict DoD units from Korea, or, at the least, hamper U.S./ROK negotiations in other areas.

5. Extent of soil and groundwater contamination off DoD installations in Korea. Surveying the extent of soil and groundwater contamination on the peninsula, including sites on MND installation, gauges the effectiveness of ROK environmental law enforcement, and provides a sample of the remediation technology available to ROK engineering firms. Both DoD and Congressional policy makers weigh the effectiveness of Korean enforcement mechanisms when promulgating remediation policy. A prerequisite to conducting remediation activities in foreign countries is demonstrated, equivalent emphasis on environmental programs within the host-nation, and the extent of contamination on the peninsula serves as a marker of the importance the ROK government places on the environment.

6. Availability of resources and technical capabilities to investigate and remediate hazardous waste sites in Korea. Even a policy which theoretically fulfills the objectives of DoD policy makers stands little chance of being effective without sufficient resources and technical know-how for execution. This issue, partially explored above, considers the "real-world" applicability of DoD remediation policy in Korea. If the Korean engineering community cannot effectively execute remediation projects using innovative, cutting-edge technologies, DoD will be hard-pressed to fulfill remediation policy

objectives within budgetary constraints. Additionally, in assessing Korea's technical capabilities in the field of remediation technology, opportunities for cooperation between the U.S. and Korea may surface, which the U.S. should exploit to enhance military and political relationships.

While this thesis did not determine the level of influence each of the issues should exert on DoD remediation policy for Korea, or attempt to formulate the optimal policy, it did identify specific themes which policy makers should consider when trying to promulgate cleanup policy and it did establish some of the relationships between issues. Triangulation served as the basis for discovering and validating these points which surfaced when each of the three exploratory methodologies were employed.

After conducting the literature review, personal interviews, and field observations, however, it became apparent that several of the issues listed above do not lend themselves to validation using all three legs of the triangulation methodology. These include:

- U.S. and ROK environmental law, and agreements between the two;
- DoD environmental policy makers' fundamental objectives;
- Cleanup precedents; and
- Availability of resources and technical capabilities.

Field observations are not possible in each of these areas; hence validation will be based on similar findings between literature review and personal interviews only. Additionally, field observations were not accomplished at non-DoD sites due to time limitations and security considerations (for MND installations). Data gathered through

literature review and interviews sufficed, however, in assessing the current level of Korean environmental law enforcement on a macro level.

Field observations were applicable only in a very gross assessment of the extent of contamination on DoD installations, and even in this category, observations were limited to contamination physically detectable at ground level. Time and resource limitations prevented actual sampling of sites, although the large pool of interviewees and available literature more than compensated for this shortcoming.

C. Degrees of Convergence

In comparing findings between the three methodologies employed, various levels of convergence appeared. These included:

1. Complete convergence—Findings were identical among the methodologies and among groups (DoD-level, installation-level, or Korean community) within a single methodology.

2. Partial convergence—Two types of partial convergence resulted:

   - Findings were similar between methodologies, but the groups surveyed within methodologies produced contradictory findings.
   - Findings were similar between groups within methodologies; however the findings between methodologies contradicted each other.

3. Divergence—Findings between methodologies and between groups within methodologies contradicted each other.

Differences either between groups or between methodologies (partially convergent or divergent findings) may appear "negative" at first. An instinctive action might be to

ignore such findings since the triangulated approach could not validate them. However, recalling the discussion on strengths of the triangulation methodology in Chapter 2, divergent findings may actually strengthen the overall thesis by providing unique, insightful factors bearing upon remediation policy formulation. In practice, such divergent and partially convergent findings established a number of relationships between issues. In addition to providing a holistic picture of remedial issues in Korea, these relationships are critical to application of decision analysis methods—one of the recommended directions for future study.

D. Findings

A summary of major findings and the level of convergence which resulted from applying the triangulation methodology appears in Appendix 5-1. Detailed explanations follow below.

1. U.S. Environmental Law and DoD Remediation Policy.

1. U.S. environmental laws do not require remediation of hazardous waste sites in Korea (***Convergent Finding***). At present, no provision of U.S. environmental law specifically requires DoD to cleanup contaminated sites in Korea, or anywhere overseas, with the exception of U.S. territories abroad (154; 156; 168). Such a requirement would infringe upon the sovereign rights of the host-nation, and therefore, is not expected to change at any point in the future. However, Congressional interest in DoD remediation activities overseas continues to increase. Section 333 of Senate Bill 936, *National Defense Authorization Act for Fiscal Year 1998*, puts forth an amendment to Title 10

USC 2706 (*Environmental Restoration*), requiring a report on environmental activities of DoD overseas to include:

> A statement of the funding levels and full-time personnel required for the [DoD] to comply . . . with each requirement under a treaty, law, contract, or other agreement for environmental restoration or compliance activities.
>
> A statement of the funds to be expended by [DoD] during such fiscal year in carrying out other activities relating to the environment overseas, meetings, and studies for pilot programs and travel related to such activities. (167)

Although the proposal still requires House approval, it suggests growing Congressional interest in DoD's restoration activities overseas.

2. Acceptability/Adequateness of DoD overseas remediation policy ***(Divergent Finding)***. Results from literature and interviews verified the current policy—cleanup is justified when a contaminated site presents "imminent and substantial endangerments to human health." However, groups tended to disagree over the adequacy of the current policy.

a. DoD policy makers defended the current policy, highlighting that differing conditions between the various countries requires a flexible remediation policy. Policy makers crafted non-specific guidelines to allow in-theater commanders maximum flexibility in tailoring their restoration program to country-unique conditions, while still ensuring human health risks were abated, and provisions of international agreements were met. If commanders felt conditions warrant more specific direction, the policy delegated authority to DoD environmental executive agents (in this case, the Commander-In-Chief (CINC), USFK) to more specifically define "imminent and substantial endangerments."

b. USFK and installation personnel believe "imminent and substantial endangerment" needs further specificity. Interviewees felt the current policy allows too much latitude in interpretation between services and between installations, which may lead to dissimilar environmental conditions at DoD installations throughout Korea. The non-specificity of remediation policy also complicates the project justification process, since priorities for similar projects, even within the same service, could differ from installation to installation.

Installation-level environmental offices suggested a standardized, health risk-based procedure for quantifying the "urgency" level associated with hazardous waste sites. DoD's relative risk site evaluation framework provides such a procedure which could be applied to Korean installations. As outlined in the *DoD Relative Risk Primer*, and Figure 7, the framework evaluates the relative risk posed by a site in relation to other sites using three factors:

- The contaminant hazard factor (quantitatively measures the relative toxicity of CERCLA hazardous substances, pollutants, or contaminants);
- The migration pathway factor (qualitatively measures the likelihood of contaminant migration from the source); and
- The receptor factor (qualitatively measures the level of risk associated with the present or future human and ecological receptors of the contaminant).

The framework measures these factors in the four media most likely to result in significant exposure—groundwater, surface water, sediment, and surface soils, and combines results in a single ranking—high risk, medium risk, and low risk. Because of

its broad application throughout DoD, environmental personnel should be familiar with its procedures, and with slight revision in the contaminant hazard factors to account for FGS-specific contaminants and MCLs, the DoD relative risk procedures should be readily adaptable to USFK installations. Chief among its advantages, the framework provides a common approach among DoD components for categorizing and prioritizing sites by relative risk, and does so in easily understood terms. An independent study of possible

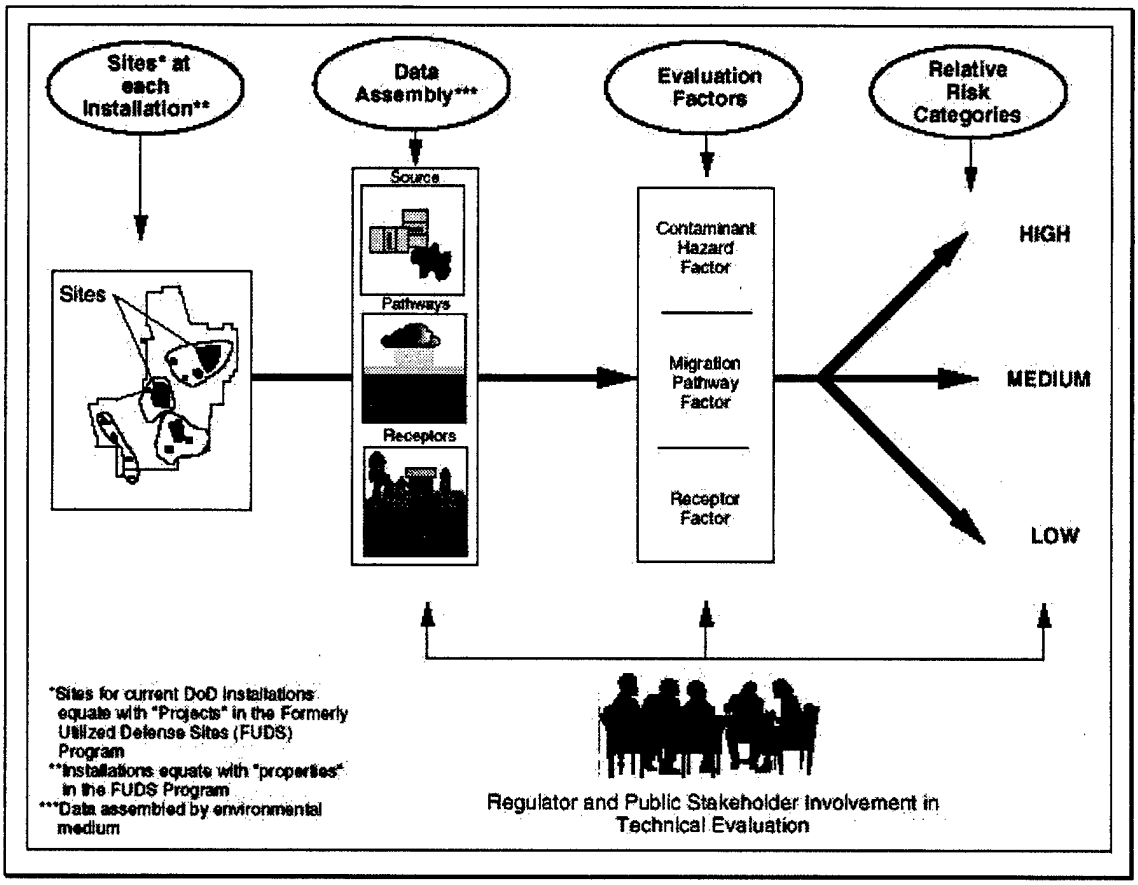

Figure 7: Relative Risk Framework (37:2)

restoration sites at Osan Air Base reached similar conclusions regarding the need for a risk-based evaluation system, and advocated use of U.S. EPA Region III's Risk-Based Concentration system (174).

c. DoD policy levies responsibility for interpreting "imminent and substantial endangerment" upon USFK; however, the organizational structure of USFK does not lend itself to adequate peacetime oversight and support of a Korea-wide restoration program. As shown in Figure 8, the Army, Air Force, and Navy components of USFK operate in separate chain-of-commands during peacetime. These separate and distinct peacetime command structures also program and allocate the funds necessary to conduct hazardous waste site assessments and execute remediation projects (as necessary). For example, Headquarters PACAF provides funds to accomplish remedial site investigations or cleanup projects at Air Force bases in Korea, either through annual O&M funds distributions to wing commanders (commanders are left to "divide the pie" as appropriate for his/her installation) or for specific projects over and above the installation's normal allotment. However, at no point in the planning, programming, budgeting and project execution process does PACAF consider the total joint environmental requirements for the peninsula. PACAF determines resource allocations strictly on Air Force mission requirements without knowledge of Army and Navy needs.

The Environmental Programs Office, a dual-hatted staff agency serving both USFK and EUSA, should have the environmental expertise coupled with cognizance of the overall joint mission in order to properly advise CINC USFK, the DoD environmental executive agent, on cleanup issues for Korea. However, EPO rarely participates in Air

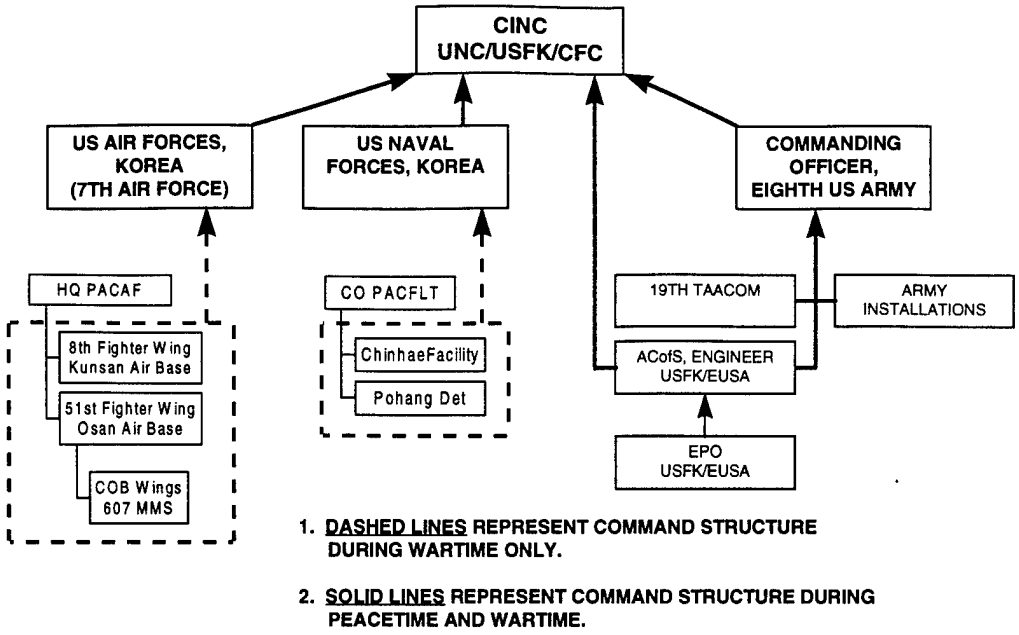

Figure 8: USFK Command Structure

Force and Navy-specific environmental matters (with the exception of coordinating with DoD installations in Korea when promulgating the Korea FGS). EPO maintains little information on either Air Force or Navy environmental programs. They maintain some information for Army installations (site investigations and ECAS reports); however, they did not have site assessments or compliance audit results for Air Force or Navy bases. In addition, EPO has very little influence over environmental funding issues even within the Army command structure, since EUSA's project prioritization and approval process is centralized at 19th TAACOM.

Much like EPO, Air Force and Navy command structures in Korea—USAFK and USNFK—also have no control over environmental funding for their respective installations in Korea. These organizations are charged with maintaining combat-capable

forces to support the overall USFK-warfighting effort in Korea; yet, they have no resources for correcting environmental hazards with direct impact on contingency operations (such as contaminated groundwater wells). Both USAFK and USNFK have influence upon the host-nation funded construction programs (CDIP and ROKFC). However, as mentioned in Chapter 4, these programs have historically supported mission-related and quality of life projects

3. Cleanup precedents set in other foreign countries influence future remediation policy ***(Partially Convergent Finding)***. Although interviewees universally believed cleanup precedents have an impact on remediation policy, they expressed different opinions on the weight of the impact. In all cases, individuals believed it will be increasingly difficult to defend SOFA provisions allowing return of installations to Korea without restoration of DoD environmental contamination as the U.S. continues to agree to some sort of restitution in other countries. In Germany alone, DoD components have returned nearly 650 installations or facilities since 1990 in which residual value off-set cleanup costs. Canada serves as the latest example of paying restitution for cleanup of hazardous waste sites. Both countries have SOFAs similar to the U.S./ROK SOFA with regard to cleanup requirements.

The differences between interviewee's responses came in whether or not they believed DoD policy or SOFAs would ever be revised to include a restoration provision based on precedents. One camp believed a restoration clause would never be included given the practical realities of fiscal constraints on the availability of cleanup funds, and the fact that other SOFAs had no such provisions. They argue that precedents shall not be

seen as relevant since each relationship is unique, and should be treated as such, requiring one-on-one negotiations to resolve country-specific requests for remediation. Another camp opined that the question of remediation on host-nation territory fell within the larger realm of international law, based largely on multilateral and bilateral agreements, and precedents. Although not enforced by any supernational sovereign body, countries such as the U.S. and Korea recognize international law, in practice, as binding provisions. As the U.S. continues its practice of compensating host-nations for contaminated sites caused by DoD operations regardless of any SOFA or other international agreement, the case supporting restoration in foreign countries becomes stronger—leading, perhaps, to adoption as a tenet of international law.

4. Current DoD remediation policy may allow ROK access to data on contaminated sites on DoD installations ***(Divergent Finding)***. Paragraph F3 of DODI 4715.8 allows free exchange of information on hazardous waste sites between the DoD and the Korean government, if the Korean government requests the information (39:14). One could interpret MOE's request for joint assessment of DoD installations as a request for data on contaminated sites, since the assessment's primary goal is identification of such sites. Once information is provided to MOE, the door is open to ROK claims of environmental law violations, particularly of the Soil Preservation Act. Since the U.S. must "respect the law of the Republic of Korea," and "abstain from any activity inconsistent with the spirit" of the SOFA (Article VII), it follows that DoD must at the very least consider remedial action for those sites which violate Korean environmental law. This is classified as a "divergent finding" since DODI 4715.8 was the only source of

information for the finding (USFK and installations personnel were not aware of this requirement).

On the other hand, Korean "respect" for DoD's environmental program may also result from full disclosure of environmental information. To this point, USFK has not provided Korean officials with any information regarding their environmental program in Korea—this includes DoD/USFK regulations and policy, the Korea FGS, ECAMP and ECAS reports, hazardous waste production statistics, etc. MOE's perception of the DoD environmental program in Korea has been solely based on NGO observations, innuendo, and rumors. Infrequent contact between EPO and their counterpart in MOE, evidenced by the fact that the last meeting of the Environmental Subcommittee of the SOFA Joint Committee was in September 1993 and verified by EPO (58), casts even further doubt on the effectiveness and integrity of the USFK environmental program in the minds of MOE. Allowing MOE access to USFK installations and environmental data should increase the level of "trust" between MOE and USFK, concerning USFK's stewardship of Korean land, given:

a. The equity between USFK/DoD standards and Korean environmental standards. In fact, portions of the USFK/DoD standards are generally higher than Korean standards, especially with regard to protection of groundwater resources, and handling of hazardous materials and hazardous waste.

b. The effort expended by USFK installations to comply with the FGS, and, therefore, Korean environmental law. Disclosure of annual ECAMP and ECAS

findings, and the priority given to their closure by installation commanders, should demonstrate USFK resolve to adhere to ROK environmental laws.

c. General conditions on USFK installations. Although access to MND-exclusive installations was not permitted, observations of ROKAF and ROKA compounds on DoD installations indicate a level of environmental stewardship no higher than that practiced by USFK organizations. Results of joint DoD/MOE assessments should show DoD's superior care of the Korean environment when compared to MND installations (EPO and USFK interviewees generally agreed with this statement). At the least, conducting joint assessments would foster a cooperative spirit between the two organizations by demonstrating USFK's willingness to air "dirty laundry" with their host.

2. International Agreements.

1. International agreements do not require DoD activities to remediate hazardous waste sites prior to their closure and return to Korea (***Convergent Finding***). The U.S./ROK Status of Forces Agreement defines the rights and responsibilities of both nations with regard to the presence of DoD personnel in Korea. Article IV specifically addresses installations and facilities and explicitly negates any U.S. liability for restoration of contaminated sites. SOFAs with Japan, Germany, and Canada contain very similar language, relieving the U.S. of any obligation to restore facilities and areas to their previous condition.

2. International agreements will be revised in future years to require remediation of hazardous waste sites in Korea ***(Partially Convergent Finding).*** Findings in the literature and interview responses varied with regard to this issue. Some interviewees

believed such a requirement will never gain Congressional support given financial restraints, the low emphasis the ROK government currently places on remediation issues, and the precedent such a requirement would set in for DoD operations in other countries. On the other hand, other interviewees suggested restoration is inevitable—that negotiated settlements between the U.S. and Germany and Canada with regard to remediation of former DoD sites may have already set a strong precedent for future remedial action. An example from literature which may foretell of future remedial requirements in Korea is the March 1993 Supplementary Agreement with Germany. The yet-to-be-enacted agreement obligates NATO forces (including the U.S.) to "bear the costs" of assessing, evaluating and remediating environmental contamination which it caused (127:6). During interviews, Korean officials expounded their belief that the current U.S./ROK SOFA was "unfair" compared with similar agreements between the U.S. and other foreign nations, and the Supplementary Agreement with Germany just adds support to their claim.

3. The SOFA may allow DoD individuals to be incriminated for violation of Korean environmental law, or held responsible for damages to third parties resulting from contamination ***(Divergent Finding)***. DoD legal officials believed that DoD individuals would never be criminally prosecuted for any environmental offense committed in Korea, placing environmental issues in the realm of tort and damage law rather than criminal law. They felt the SOFA would allow the U.S. to exercise exclusive jurisdiction should the ROK government target a DoD individual for violation of Korean environmental law. However, an examination of criminal law and the SOFA seems to yield contrary findings.

a. Criminal Law. The Cornell University School of Law's Legal Information Institute defines a "crime" as:

> Any act or omission (of an act) in violation of a public law forbidding or commanding it. Most crimes (with the exception of strict-liability crimes) consist of two elements: an act, or 'actus reus' and a mental state, or 'mens rea.' Prosecutors have to prove each and every element of the crime to yield a conviction. (29)

Violation of Korean environmental law could certainly fit this definition of a "crime," under the assumption that the U.S. legal definition matches the Korean legal definition. Two examples of successfully prosecuted criminal cases against non-U.S. personnel demonstrate Korean willingness to enforce provisions of their environmental law (see Chapter 4, Section B2, *Korean Environmental Policy and Current Environmental Conditions*). In a great many cases, the U.S./ROK SOFA protects U.S. military personnel, their dependents, and contractors against prosecution under Korean laws (reference Chapter 3, Section C3, *Applicability of ROK Environmental Laws to DoD Forces in Korea*, for supporting evidence). While Korea has never exercised its jurisdiction over environmental crimes in the past, recent trends and increasing environmental awareness among the Korean populace may change this pattern.

In addition to possible Korean criminal prosecution, DoD violators of Korean environmental law could also face penalties imposed by U.S. law. Section 956 of Chapter 45 of Title 18, United States Code, states:

> Whoever, within the jurisdiction of the United States, conspires with one or more persons, regardless of where such other person or persons are located, to damage or destroy specific property situated within a foreign country and belonging to a foreign government . . . with which the United States is at peace, or any . . . airport, airfield, or . . . public structure, . . . , or cultural property so situated, shall, if any of the conspirators commits an act within the jurisdiction of the United

States to effect any object of the conspiracy, be imprisoned not more than 25 years. (155).

The preceding is an example where violators of Korean environmental law could face criminal prosecution even when the U.S. retains exclusive jurisdiction over the case. Despite the extenuating circumstances (prosecutors must show intent to damage and conspiracy to damage), the claim that U.S. military personnel in Korea "would never be criminally prosecuted for any environmental offense" may not be true. However, even if DoD legal advisors are successful in exercising exclusive jurisdiction to protect DoD members from criminal prosecution, damage claims arising from tort law may result in monetary penalties.

b. Tort Law. "Tort" denotes a common law violation for which a court provides compensation for damage—physical or psychological (144:6). Within U.S. common law, there exists a general legal duty to avoid causing harm to others, through acts of omission or commission. Carelessness in exercising this duty which results in some harm or damage to others may result in a lawsuit through which the injured can seek compensation (144:6). The U.S./ROK SOFA contains similar avenues for Korean citizens to gain restitution for damage caused by DoD members (43:38-42). Historically, Korean citizens have not filed many damage claims, which could be a matter of cultural differences as much as their ignorance of legal avenues for gaining compensation. Interestingly, according to interviewees, DoD installations have repeatedly provided payment in the past for damage allegedly caused by DoD operations rather than enter litigation with the injured party. Examples of cases include destruction of crops due to misapplication of herbicide, contamination of crops by POL emanating from on-base

sources, DoD-caused contamination of local water sources, damage to facilities due to aircraft accidents, and damage to natural resources from training exercises (27). Interviewees and literature show a trend similar to criminal cases of increasing tort claims filed by Korean citizens against Korean firms during the past decade.

3. ROK Environmental Law and Current Environmental Conditions.

The level of ROK environmental awareness and compliance with Korean environmental law is increasing ***(Convergent Finding)***. The data consistently highlighted the importance of two prerequisites which Korea must demonstrate before U.S. policy makers consider revising the current DoD remediation policy: (1) a strong emphasis by the Korean government in preserving the environment as exemplified by stringent environmental laws in various media (air, surface water, groundwater, soil, and sediments); and (2) a commitment by the Korean government to enforce those laws. Findings from literature review and personal interviews unanimously supported Korean progress in fulfilling the first prerequisite. The past decade witnessed explosive growth in ROK environmental legislation and funding, which U.S. policy makers generally regard as positive signs of increased Korean environmental awareness. In addition to the increase in number of laws, the stringency of those laws have also increased. In many cases, Korean environmental laws meet or exceed U.S. EPA standards. In fact, interviews with Korean researchers revealed that MOE used European standards as a baseline when promulgating the 1995 Soil Preservation Act, which specify MCLs more restrictive than U.S. MCLs in some cases (see Table 18 below).

Table 18: Comparison Between U.S. and European Soil Standards, Select Analytes (177[1])

Contaminant	U.S. RCRA Action Levels (mg/kg)	European Soil Standard Action Levels (mg/kg)
Arsenic	80	29
Cadmium	40	0.8
Chromium	400	100
4,4-DDT	2	Lowest Detectable Limit
Lead	100	85
Nickel	2,000	210
Tetrachloroethylene	10	0.01
Toluene	2,000	0.05
Trichloroethylene	60	0.001
Xylene	200,000	0.05

[1]Soil standards obtained during interview with MND.

Assessing the efficacy of Korean environmental enforcement proves more problematic. Although findings seem to indicate an improvement, U.S. interviewees still believe Korea's enforcement requires substantial improvement. Top-level DoD policy makers felt Korea must demonstrate enduring and consistent resolve in cleaning up its own environmental mistakes, especially those attributable to MND operations, before the U.S. agrees to expend increased resources to remediate contamination on DoD installations.

In past years, Korea has focused its energies in pollution prevention and conservation measures, regarding remediation of soil and groundwater as technically futile. Nevertheless, work continues in Korean universities and research centers, aimed at developing remediation technologies and a better understanding of the fate and transport of contaminants in the soil and groundwater. Korea has undertaken a few remedial projects, and aims to align more resources toward this end, especially with regard to

cleaning up landfills and other contaminated sites in close proximity to urban centers, agricultural areas, and drinking water sources.

As demonstrated in Chapter 3, MND in particular has shown a strong commitment to environmental preservation and restoration in recent years. The events in Chapter 3 with regard to MND "openness" are precedent-setting changes for an organization considered "untouchable" by government and civilian entities in Korea. MND's willingness to share information and their apparent embrace of an environmental ethic, evidenced by action and words, should signal DoD, and especially USFK, to re-examine their policy with regard to environmental restoration in Korea. For many years, USFK used MND's "closed-door" policy and apparent disregard for the environment as an excuse to prohibit joint environmental assessments on DoD installations, restrict ROK access to ECAMP and ECAS reports, and deny review of the Korea FGS. U.S. policy makers felt DoD forces in Korea should not be held accountable for Korean environmental law violations if the Korean military was not leading the way (58; 89; 168). Now that MND has officially instituted an environmental program and appears to have taken steps toward compliance, the basis for much of USFK's "closed-door" remediation policy regarding the environment has disappeared.

4. Current Environmental Conditions at DoD Installations in Korea.

1. Suspected and confirmed hazardous waste sites, contaminated primarily with petroleum, oils and lubricants (POL), organic solvents, and heavy metals, exist at numerous locations throughout the peninsula ***(Convergent Finding)***. Examination of available site investigations conducted by the Corps of Engineers, Far East District, Air

Force Center for Environmental Excellence (AFCEE), 240th Civil Engineer Flight, and Woodward-Clyde Federal Services at Kunsan Air Base, Osan Air Base, Taegu Air Base, Camp Carroll, and Camp Market confirmed the existence of at least eight sites requiring action to remediate significant health effects and/or prevent migration of contaminant plumes to off-base areas (110; 151; 152; 153; 174; 175; 176). These sites include:

- Kunsan Air Base: North POL Storage Area
- Osan Air Base:
    - AMC Ramp Site and POL Tank Farm Area (adjacent areas)
    - Bulk Storage Tanks 8 and 9
    - Building 942, Heating Facility
    - Building 1073, DV Quarters, and adjacent communications manholes
- Taegu Air Base: JP-4-Contaminated groundwater wells
- Camp Carroll: TCE-Contaminated groundwater wells
- Camp Market: POL-Contaminated soil (Vehicle Disassembly Area)

In addition to these sites, a number of additional areas require preliminary assessment to determine the extent of contamination, migration pathways, and possible receptors. At Osan Air Base alone, another 37 sites were identified in a recent restoration program survey (174). Review of the most recent Environmental Compliance Assessment and Management Program (ECAMP) and Environmental Compliance Assessment System (ECAS) reports, combined with personal accounts from installation personnel and field observation revealed approximately 79 additional sites at USFK installations across the peninsula with possible contamination. These include effluent

from wastewater treatment plants that treat mixed influent from industrial operations and domestic sources and stormwater effluent which have never been analyzed for contaminants, leaking aboveground and underground fuel storage tanks, soil stained from POL spills, and groundwater with excessive levels of organic solvents and heavy metals (60; 61; 62; 63; 64; 65). Sites identified by the ECAMP and ECAS audits for which comprehensive investigations have not been accomplished warrant a closer look by qualified, experienced technical personnel to ensure dangerous conditions do not exist or will not exist in the future.

In all cases, including those with confirmed contamination, the scope of the problem remains unknown. Additional investigation is required to adequately characterize the site hydrogeology, locate contaminant source(s), estimate the quantity of contaminant(s), and predict the speed and direction of contaminant plume(s), and assess risk to human health. At Kunsan AB, Taegu AB, Camp Carroll, and Camp Market, several sites are located in close proximity to the installation boundary. Contaminant plumes may begin to migrate off-base if remedial projects are not undertaken soon.

At nearly every USFK installation, wastewater treatment plants are severely undersized and/or outdated. The majority of bases treat wastewater from domestic and industrial sources using septic tanks or Imhoff tanks, which only provide primary treatment. Effluent from the plants, which discharge to off-base streams, rivers, and estuaries, has rarely been analyzed for heavy metals and other potential contaminants. At stateside locations, wastewater effluent would not normally be considered a source of hazardous waste contamination. However, the poor management of industrial wastewater

(often containing heavy metals and organic solvents from metal plating, painting, and other maintenance operations) and archaic treatment technology prevalent at many USFK installations make wastewater effluent a possible source of hazardous wastes in Korea.

2. Drinking water wells at several main operating bases (MOBs) and collocated operating bases are contaminated with POL and organic solvents, potentially impacting DoD and ROK military units ***(Convergent Finding)***. This finding is presented separately from the information above because it has a potential impact on warfighting capabilities of DoD and ROK military units (where ROKAF and/or ROKA units are jointly stationed). Although most of the MOBs obtain drinking water from commercial sources, drinking water wells serve as contingency sources of water should primary, civilian sources become contaminated or services interrupted. The possibility of such a scenario becomes increasingly likely in a wartime situation. Examples of groundwater contamination at the MOBs include:

a. At Osan Air Base, home of the most forward-deployed Air Force wing in the world and only 48 miles from the North Korean border, 24 wells—the majority of Osan's secondary water source—have been shut-down due to contamination from various POL products (173; 174).

b. At Camp Carroll, where depot-level maintenance is conducted on all of the Army's vehicles and heavy equipment (including armored combat vehicles) in Korea, seven of the installation's 13 groundwater wells have been shut down due to high levels of trichloroethylene. Unlike Osan, Camp Carroll's wells provide its primary water source (83; 153).

c. The four wells providing drinking water to the dormitories on Suwon Air Base are contaminated with excessive levels of trichloroethylene. The local city water system now supplies all drinking water to this portion of base—no contingency water source exists should the local system become inoperative or non-potable (52:14-2; 104; 107).

d. Seven water wells and a connection with the local city's water system provide drinking water for Taegu AB. Two of the seven wells are currently shut down due to jet fuel contamination (50:14-3). A pump-and-treat system was installed in March 1982 to remediate the source of the contamination; however, effluent from the system, which discharged into a local stream, contained contaminants in excess of ROK and USFK limits. As a result, the Osan Air Base Bioenvironmental Engineering Office ceased remediation of the site in 1996, although the groundwater remains contaminated with high levels of petroleum hydrocarbons. Recent conversations with base personnel indicate the system was restarted on 4 Aug 97, with modifications to the contaminant removal system to meet effluent limits. The history and analysis of groundwater contamination at Taegu AB is the subject of an on-going investigation focusing on the performance of the pump-and-treat system and movement of the JP-4 jet fuel at Taegu AB. Results are expected in late 1997 (100).

e. Two of 23 groundwater wells at Camp Casey, which houses the most forward-deployed division in the U.S. Army, are contaminated with POL. Although the well system supplies only 25 percent of the total potable water to the installation, the post's proximity to the North/South Korea Demilitarized Zone (less than 10 miles) and

the large population it supports (more than 8,800 personnel), make Camp Casey's commercial and surface water supply a likely target during a contingency. In addition, installation environmental engineers reported that no site investigation has ever been conducted for the contaminated wells—thus, the source of contamination is unknown and the resultant plume may be migrating to other locations on post or moving off-post.

5. Opportunities for Cooperation.

Numerous opportunities for cooperation between DoD and the ROK government exist in the field of environmental remediation ***(Convergent Finding)***. Environmental training, advanced education (graduate and post-graduate studies), and technology transfer are the main areas in which significant inroads can be made to improve the overall U.S./ROK relationship (56; 168; 177). Interviews with both DoD and ROK officials indicated both organizations would lend support for such cooperative ventures; however, little progress has been made thus far (56; 168; 177). The infancy of Korea's remedial capability and MND's environmental program as a whole establish cooperative ventures as an "easy target" for success. At least one environmental firm claims to have expertise in such innovative cleanup technologies as soil washing, in-situ and ex-situ bioremediation, and soil vapor extraction (76), though typically, physical ex-situ techniques, such as dig-and-burn are used for remediation (177). Although ROK research and development funding in environmental technology has risen dramatically over the past few years (701%), it still falls short of perceived needs (114:182). Cooperative efforts between DoD and the ROK government would assist Korea in obtaining the tools

necessary to meet their environmental challenges while fostering good will between both governments.

E. Generalizations

1. Suspected Hazardous Waste Sites. As chronicled earlier in this chapter, a number of confirmed and suspected hazardous waste sites exist on DoD installations throughout Korea—a finding supported by previous investigations, interviewee testimony, and independent field observations. Nineteen (95 percent) of the twenty HQ USFK and installation personnel interviewed firmly believed, based on personal observations and experiences, that hazardous waste sites existed on DoD installations in Korea. One interviewee from the legal field had no knowledge of such sites, but regarded his opinion as naive due to limited experience in the military legal profession and environmental law (three months). Each of the five installations visited displayed some visible signs of possible soil and/or groundwater contamination, ranging from the obvious (POL odors emanating from, and stains on soil, installation of pump-and-treat systems, areas secured from personnel entry due to known contamination) to the questionable (distressed vegetation, oily sheens on surface water). Each base, however, had at least one obviously contaminated site. Existing literature describing hazardous waste sites at Korean DoD installations consisted of:

- Four in-depth site investigations (involved chemical sampling);
- Four consolidated studies (review of existing data, studies, and, in one case numerous personal interviews);

- Two base support plans (Suwon AB and Taegu AB) reporting areas of known contamination; and
- Six compliance assessment reports highlighting the possibility of contaminated sites at numerous Army and Air Force locations based on field observations and limited personal interviews.

Despite the preponderance of evidence suggesting the strong possibility of contamination, all categories of literature lacked elements necessary to adequately characterize hazardous waste sites. In reviewing the existing site investigations, several shortcomings become evident:

a. Unknown quantity of contaminant in subsurface. Only one study (6) included an estimate of the quantity of contaminant(s) present in the subsurface. Without a known quantity, the plume size and extent of migration, especially with respect to vertical depth, are difficult to determine.

b. Unknown source of contaminant. A majority of the investigations (75 percent) did not pinpoint the exact location(s) of contaminant source(s). Sampling results from relatively few monitoring wells mapped areas with high concentrations of hazardous wastes. However, without known source locations, the studies could not determine future paths of migration. In a few cases, such as the contamination of the groundwater aquifer at Camp Carroll and Taegu Air Base, determination of migration paths are critical due to plume proximity to the installation boundary. In addition, elimination of the contaminant source may be the only way to cleanup the site, especially if the source continues to emanate hazardous waste after a remediation technology is employed.

c. Unknown background concentrations of contaminants. Determination of background concentrations were not accomplished in any of the literature reviewed. Knowledge of naturally-occurring contaminant concentrations is essential to differentiating between anthropocentric and intrinsic pollutants, which, in turn, influences risk assessment and cleanup levels.

d. Poorly characterized hydrogeologic conditions. With one exception (175), investigators did not perform hydraulic tests on wells with the intent of identifying hydraulic characteristics. This includes the JP-4 spill site at Osan Air Base, where an estimated 500,000 to 700,000 gallons of JP-4 was released. Since the accident occurred in 1986, no less than 4 studies have been accomplished and 98 boreholes and 16 monitoring wells installed, but no attempt to characterize the source of free product, nor the subsurface conditions, has ever been undertaken (6:2, 5). Estimation of contaminant transport (speed and direction), and infiltration rates for source definition is not possible without a thorough understanding of the subsurface hydrogeology.

e. Risk assessment not thoroughly accomplished or not accomplished at all. Given the current remediation policy, it seemed surprising that only one study (175) adequately assessed hazardous waste sites for human health risks. Common discrepancies included:

(1) Failure to address all contaminant pathways. In all but the Kunsan study (175), investigators overwhelmingly focused on the groundwater pathway, ignoring exposure to contaminated dust and volatized wastes, and uptake and bioconcentration of contaminants in flora and fauna.

(2) Failure to fully address off-base receptors with respect to future land use. Investigators probably neglected consideration of future land use since SOFA provisions do not currently require environmental remediation in conjunction with base closure. As mentioned in earlier sections, however, cleanup precedents and heightened ROK environmental awareness and compliance may lead to a natural evolution of international environmental policy and law requiring future remediation of hazardous waste sites in foreign nations.

(3) Use of MCLs in lieu of dose/response data to determine risk to human health. Only three studies made reference to published cancer risk and hazard quotient data when assessing human health risk (174; 175; 176). Other investigations relied on MCLs as the determinant of risk. (The 1993 AFCEE health risk assessment and remedial alternative review of Osan Air Base used health-based risk to determine the "potential for adverse health effect" (110). However, the report's authors did not specify the basis for their conclusions, i.e., where cancer risk factors and/or hazard quotients were derived from.)

In addition to these issues, which support the finding of inadequately scoped hazardous waste sites mentioned earlier, the absence of a standardized risk model and appropriate risk thresholds for investigators to apply when conducting site investigations seems especially troubling. The National Academy of Sciences (NAS), in a 1983 report on risk assessment in the federal government, suggested a four-step approach to risk assessment, illustrated in Figure 9 (102:192). Figure 9 includes an additional step—the

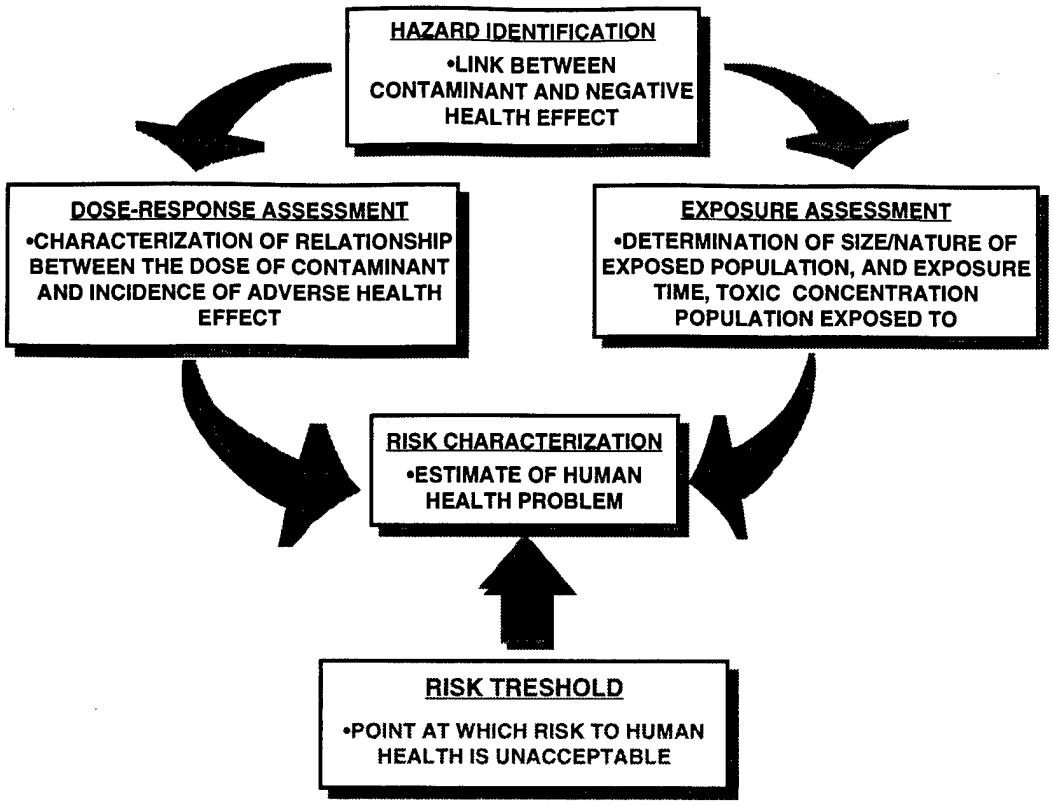

Figure 9: Four-Step, Risk Assessment Approach (102:192-193)

determination of a risk threshold influencing ultimate risk characterization. In the United States, this step is accomplished by the Record of Decision process, which incorporates the views of the local community, state environmental regulators, and installation-level senior leaders levied with site restoration responsibility. The group collectively reviews the risk assessment produced by the scientific community (installation environmental engineers), and makes a final decision regarding cleanup strategy based on political, economic, technical, and health-risk factors.

The report outlined two other recommendations pertinent to our discussion of DoD overseas remediation policy:

- a clear conceptual distinction between assessment of risks and the consideration of risk management alternatives; that is, the scientific findings and policy judgments embodied in risk assessments should be explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies (123:151); and

- The process followed by the government for adoption of inference guidelines should ensure that the resulting guidelines are uniform among all responsible agencies and are consistently adhered to in assessing the risks of individual hazards. (123:166)

Since the report, DoD has devised several risk-based approaches to sequence its restoration program—the Relative Risk approach being the most recent (37). The relative risk model and present DoD policy for stateside restoration fulfill both NAS recommendations by (1) devising a clear methodology for assessing risks without specifically defining a risk threshold or amount of a hazardous substance, which, if exceeded, will trigger remedial action; and (2) mandating uniform application across all services at all installations. The ROD process embodies the risk management approach to determining the ultimate remedial strategy and incorporates the "political, economic and technical" considerations mentioned in the NAS report.

Current DoD overseas and USFK remediation policy do not appear to fully comply with all NAS recommendations:

1. Although both DoD and USFK policymakers inherently recommend use of a risk-based approach by dictating "imminent and substantial endangerments to human health" as the sole criteria for justifying remediation projects, they do not specify adherence to a single risk-based approach, such as the NAS four-step process.

2. Policy does not mandate clear separation of scientific assessment and risk management considerations. Record of Decision-type proceedings are not required, and installation commanders have complete responsibility for determining a risk threshold which invokes remedial action, and relevant cleanup standards. The lack of a multi-group quorum for deciding cleanup actions acceptable to both the liable party and the local community intrinsically mixes scientific findings and policy judgments, especially since the public is not involved in the ultimate cleanup decision. While SOFA provisions and legal issues may negate any requirement to include host-nation involvement in cleanup decisions, political considerations, such as ROK environmental awareness, cleanup precedents, and the state of U.S./ROK relations, should influence remediation decisions given the possibility of future remediation liability.

3. Policy allows installation commanders the latitude to define risk thresholds and cleanup standards in accordance with local conditions. While it provides maximum flexibility for commanders, the policy also provides the opportunity for clearly divergent cleanup guidelines and standards to exist among services, and even within the same service (47; 48; 49).

The lack of clear risk-based guidance has a more significant effect than non-adherence to NAS recommendations. Without such guidance, any future attempt to conduct investigations of suspected hazardous waste sites will net the same results as it has in the past—no conclusive recommendation other than further study, or widely divergent cleanup recommendations. In recent studies, Kunsan Air Base engineers applied the State of Hawaii Department of Health's (DOH) risk-based deterministic

model, while a study at Osan Air Base employed the EPA Region III Risk-Based Concentrations (174; 175). Comparisons of allowable contaminant thresholds for drinking water are shown in Table 19. Employing these thresholds can yield very different results—and, consequently, very different recommendations with regard to remedial action.

Table 19: Comparison of DOH Tier I Action Levels and EPA Region III Risk-Based Concentrations (174; 175)

Contaminant	Threshold (mg/L)	
	DOH Tier I Action Levels	EPA Region III RBC
Benzene	1.7	0.36
Toluene	2.1	750
Ethylbenzene	0.14	1,300
Xylene	10	12
Benzo(a)pyrene	0.0002	0.0092
Acenapthene	0.32	2,200
Fluoranthene	0.013	0.92
Napthalene	0.77	1,500
TPH-Gasolines	NS	Not Given

The adoption of risk-based standards to determine "imminent and substantial endangerment" also engenders controversy concerning carcinogenic versus non-carcinogenic responses to a particular toxin. The Korea FGS defines "imminent and substantial endangerments" in reference to remediation of leaking USTs as, ". . . acute injury or death, rather than illness or injury typically caused by long term, chronic exposure" (165:19-2). The key assumption for non-carcinogens is that there exists an exposure threshold—any exposure less than the threshold would be expected to show no increase in adverse effects above natural background rates (102:208). For substances that

induce a carcinogenic response, an assumption is made that exposure to *any amount* of the toxin will create some likelihood of cancer (102:201). A related theory, known as the one-hit hypothesis, states that a single genotoxic (DNA-altering) event can lead to some nonzero probability of cancer; hence, the longevity of exposure does not influence illness, other than increasing the probability of getting cancer. A *single exposure* may cause cancer. By defining "imminent and substantial endangerment" as they have in the FGS, USFK has presumably chosen to ignore the effects of carcinogens and placed emphasis on non-carcinogenic effects.

2. Goal-Setting Implications.

Paragraph D2 in this chapter detailed arguments for and against non-specific DoD overseas remediation policy. Recall that DoD policymakers defended their stance for non-specific remediation objectives based on flexibility. USFK personnel criticized such policy, highlighting the excessive variance in cleanup decisions which result from the current policy. The previous section supported installation claims, using the outcome of two studies as an example of the divergent conclusions possible with adoption of two different risk-based approaches.

A review of literature from the organizational behavior field points to another, perhaps more notable effect which may arise from unclear goals. Edwin A. Locke, an organizational theorist, surmised in 1968 that specific goals result in a higher level of individual performance than do no goals or a generalized goal of "do your best" (91:824). Locke based his theory primarily on a series of well-controlled laboratory experiments with college students who performed relatively simple tasks (e.g., adding numbers) for

short periods of time. A follow-up field study conducted by Gary P. Latham and Locke attempted to apply laboratory findings to the field. Logging study by Latham and Locke focused on goal-setting as method of increasing productivity within the logging industry at no cost. Managers received training and instruction to establish specific goals (number of trees felled per week) based on time-and-motion studies. Experimenters delegated authority to the managers to maximize productivity, given the basic knowledge to choose an appropriate operational goal and devise a plan to reach their goal. During the 12-week experimental period, productivity was (statistically) significantly higher in the goal-setting group compared with the control group. Moreover, absenteeism was significantly lower in the goal-setting group as well (90:40).

Some psychologists legitimately questioned whether something so deceptively simple as setting specific goals can increase the performance of employees in real organizational settings (91:825). Therefore, since 1968, numerous studies, both in the laboratory and in the field, have been conducted by various researchers to confirm Locke's original findings. Three reviews, accomplished in 1975, 1981, and 1987, attempted to survey the academic literature for evidence supporting the goal-setting theory. The first review included 27 published and unpublished reports of field research encompassing widely varying occupational groups (vending machine servicemen, keypunch specialists, skilled technicians, salespersons, telephone repairmen, truck unloaders, loggers, typists, assembly line workers, research and development managers, and surveyors. Twenty-six of the 27 reports—96 percent—supported Locke's idea of specific goal setting as a method of boosting work performance (91:830).

The second review surveyed studies accomplished between 1968 and 1980. The group of reviewers looked at not only goal specificity, but the difficulty of goals as a driver for increasing work performance. Overall, 48 studies partly or wholly supported the hypothesis that hard goals lead to better performance than medium or easy goals; 9 studies failed to support it. Fifty-one of 53 studies partially or wholly supported the view that specific hard goals lead to better performance than "do-your-best" or no goals. Combining the two sets of studies, 99 out of 110—90 percent—studies found that specific, hard goals produced better performance than medium, easy, "do-your-best, or no goals (99:131).

The final study used a meta-analytic technique to search for and compare findings of published research between 1966 and 1984. Meta-analysis refers to a statistical process enabling the reviewer to aggregate research findings across studies by using both inferential and descriptive statistics from the studies reviewed (108a:54). Besides permitting quantitative rather than qualitative gathering of results, as had been done in previous reviews, meta-analysis provides a statistical estimate for the percentage increase in productivity expected when specific hard goals are used in an organization (108a:56). Reviewers surveyed 54 studies to analyze the effect of difficult goals on performance, and 47 studies for goal specificity analysis. They concluded that goal difficulty and goal specificity/difficulty were strongly related to task performance across a wide variety of tasks and in both laboratory and field settings. The authors go on to say:

> If there is ever to be a viable candidate from the organizational sciences for elevation to the lofty status of a scientific law of nature, then the relationships between goal difficulty, specificity/difficulty, and task performance are most

> worthy of serious consideration. . . the evidence from numerous studies indicates that these variables behave lawfully. (108a:74)

For goal difficulty, meta-analysis techniques estimated the productivity increase at 11.63 percent; similarly, for goal specificity/difficulty, the increase was estimated at 8.88 percent (108a:76).

These findings certainly foretell a gloomy future for the DoD overseas restoration program given current policy objectives—remediation is justified for those sites presenting an "imminent and substantial endangerment to human health." An additional case study can be drawn from the stateside Air Force restoration program. In its early stages of development, the Air Force established vague goals and promulgated few guidelines to environmental mangers, who had free reign to develop programs based on individual assessment of site risks. The result, as stated in Chapter 4, was ineffective and inefficient management of DERA resources due to inept project estimates and extremely fluid restoration requirements at Air Force bases. The Air Force countered with adoption of the DoD relative risk assessment system, a strategic objective to cleanup those sites with the highest risk to human health, and a system for measuring accomplishment of this objective (46:3). The result of increased specificity and accountability of the Air Force restoration program has been the estimate that the entire Air Force program will be complete by 2007—not just high risk sites, but all sites (70).

If one accepts the assumption that success of the DoD restoration program in Korea ultimately depends on the performance of DoD members charged with executing the program, then this discussion on goal specificity and difficulty certainly supports a prediction of program failure, or, at the least, ineffective and inefficient execution.

3. Linkage Between Affluence and Environmental Quality/Awareness. An entire section of Chapter 3 was devoted to documenting the amazing economic growth experienced by South Korea over the past 44 years. Latter portions of Chapter 3 highlighted the growth of environmental legislation during the late 1980s/early 1990s, attempting to draw a parallel between affluence and environmental awareness. It is widely thought that poverty breeds environmental degradation; that the poorer a country is, the less resources it has to expend on "fixing" its environmental problems (148:309). As a developing country attains "developed" status, the value it places on environmental quality rises with its gross national product (GNP).

However, lack of funds do not necessarily translate to lack of interest in the environment. Many developing countries have fairly elaborate structures of rules and regulations aimed at conserving resources (148:309). Recall that Korea's first environmental law, the New Forest Law, was passed in 1961 to re-forest the peninsula—this during a time when per capita GNP was $87 and the life expectancy was about 54 years (23:15). In fact, as countries become more and more developed, certain pollution indicators actually rise, such as the per capita municipal wastes and carbon dioxide emissions (124:22; 148:311). South Korea displays many of the signs of a developed country in this regard (113:100). Their attention to the environment during their formative years and their present state of environmental legislative development attest to their continued emphasis on the environment.

In addition to attempting to demonstrate the relationship between economic growth and environmental awareness, Chapter 3 illustrated the results attainable by the

Korean government when it decides to focus its attention on a specific area. For roughly three decades, the ROK political machine had one primary goal: assure South Korea's lasting sovereignty based on a strong economic foundation. To a large extent, the ROK government has accomplished their original goal, and is now redirecting its energies in other areas, including the protection and preservation of the environment not only on a national scale, but on a global scale as well (see Appendix 5-2).

This emphasis on Korean environmental awareness and development was included because of the exceptional weight Congressional and DoD policy makers place on this issue when formulating remediation policy. If DoD policy makers and Congressional leaders doubt Korea's commitment to the environment, they only need look at their economic track record and compare it to Korea's environmental track record within the last ten years.

4. Funding *(Concurrent Finding)*.

Although not an "established" influence on remediation policy, funding certainly affects USFK's ability to execute any policy promulgated by DoD. In a roundabout way, funding actually influences remediation policy for Korea, since even the most protective policy, cognizant of human health risks and damage to the environment, is not viable if it does not account for economic realities. An overly-protective policy could incur tremendous resource deficits and result in non-compliance. An under-protective policy would compromise human health. Therefore, a balance must be struck somewhere in the middle.

To this point, DoD has left the determination of where the "over/under" protective line should be drawn to USFK. USFK, in turn, has delegated that authority to the installations. And the installations, already strapped for resources and with little say in their overall budget, have nowhere to turn. This was the overwhelming response received when installation personnel were asked to characterize the remediation program at their installation.

A partial solution to the funding dilemma was offered earlier—have Korea pay for remediation of contaminated sites resulting from ROK-funded construction projects. One could certainly make a strong case for such a policy, since these projects are managed, from design to construction completion, by the MND. Contamination of soil and groundwater due exclusively to poor design (absence of pollution and/or contamination control devices such as secondary containment of underground fuel storage tanks) and/or poor construction techniques (faulty fuel pipeline welding) should not be the responsibility of USFK organizations, since USFK engineers had little say in either design or construction.

A more fundamental approach, which attacks funding at the Congressional level and is achievable within the DoD organization, will be offered in the next chapter.

F. Shortcomings In Research Techniques

Several shortcomings in each technique employed in this thesis became evident during the research. To conceal these shortcomings would only hurt the credibility of the overall study and make future research in this area all the more difficult. Hence, a short discussion of difficulties encountered follows.

1. Literature Review. A tremendous amount of information was obtained from a variety of sources—academic journal articles, site investigations/assessments, official correspondence, government white papers and studies, and legal documents, to name a few. However, the majority of information came from U.S. sources. These sources provided a detailed, in-depth picture of issues surrounding remediation policy formulation as understood by U.S. policy makers. A better understanding of the Korean environmental program would have been possible if a wider variety and larger number of Korean sources were canvassed.

The language barrier proved to be the most significant barrier in obtaining and *comprehending* Korean sources. In many cases, full-text ROK law documents, such as the Soil Preservation Act and Drinking Water Management Act, and interpretive documents were available to researchers, but printed in the Korean language (Hangul). Other documents, including the 1997-1998 MND White Paper, details of major ROK environmental laws, and commentary from MOE officials and NGOs have recently been released in Korean on the Internet, and would have added to this thesis if not for the language barrier.

Previous research looking at Korean government documents evaluating environmental conditions have shown the accuracy of the measurements reported and the methodologies on which they are based to be widely suspect (59:7, 21). While numerous Korean government documents were used in this thesis, environmental data and statistics were used exclusively for establishing trends rather than establishing fact.

2. Personal Interviews and Field Observations. While the researchers were successful in questioning the intended groups, conducting field observations, and obtaining useful information from both activities, a few problems were encountered:

a. Some of the intended interviewees were not available to participate in the interview process. These included the 7th Air Force Civil Engineer and his staff; and the Environmental Division Chief and the staff at Headquarters U.S. Air Force.

(1) 7th Air Force Civil Engineer: At the time of the site visit, the 7th Air Force Civil Engineer (7 AF/CE) and two-thirds of his staff were being replaced with newly-arrived personnel. However, in a short discussion with the incoming 7 AF/CE, he pointed out that his office did not historically concern itself with environmental issues. Policy flowed from Headquarters USFK directly to the Air Force installations in Korea with little or no direction from 7 AF/CE. As such, he and his staff could not contribute any information to the study. The 7AF/CE staff is slated to receive an additional officer, dedicated specifically to environmental issues at Air Force installations and collocated operating bases in Korea; however, the slot will not be filled until fiscal year 1998 at the earliest (130).

(2) Environmental Division, Headquarters U.S. Air Force. As was the case with the 7 AF/CE, the Environmental Division chief and the individual on the headquarters staff with responsibility for international environmental policy were not available for questioning. However, the former Environmental Division Chief served as a very capable and knowledgeable surrogate.

b. All questions devised for the Korean interviewees could not be asked, either due to time constraints or language barriers. The information gleaned, however, still proved exceptionally useful for substantiating findings from the literature review, and in manifesting "interview-unique" items not found in historical documents, nor known by their DoD counterparts.

c. The site visit at Osan Air Base was shortened during one of the two days available for interviews/field observations because of a base-wide operational exercise. Despite the unexpected event, the majority of interviews and a tour of possible hazardous waste sites, led by the Deputy Chief, Environmental Flight, were completed prior to the exercise. Staff members provided additional documentation and answers to remaining interview questions via electronic mail (e-mail) correspondence. The only negative effect felt from the exercise dealt with the inability to complete more extensive field observations at Osan Air Base.

d. Site visits to the three Army installations and two Air Force installations proved too short to accomplish substantial field observations to confirm interviewee testimony and literature findings, and to uncover findings unique to the visit itself (not duplicated with findings from interviews and literature). Although the purpose of the visit was not to conduct in-depth site characterizations such as those required in the United States for compliance with CERCLA mandates, more time at each installation could have exposed more evidence of possible contaminated sites. For example, the 240th Civil Engineer Flight, Buckley Air National Guard Base conducted an independent site visit of Osan Air Base between 31 August and 12 September 1997, for the purpose of

producing an Environmental Restoration Management Action Plan. The four-person team contacted approximately 50 personnel, reviewed historical documents and conducted extensive tours of the installation during the 13-day period. Their draft report concluded that 42 possible restoration sites existed on Osan, significantly more than this thesis originally discovered prior to the Buckley site visit.

e. Field observations and interviews should have been arranged with ROK military units collocated on DoD installations and collocated operating bases. Field observations at Kunsan Air Base supported possible poor environmental management practices by the ROKAF unit stationed there, which may have already led to soil or soil/groundwater contamination on Kunsan Air Base. The difficulty of pinpointing sources of contamination once a spill has occurred, especially for DNAPLs, could lead to contentious debate between DoD and ROK officials should remediation of such sites be required in the future. Investigation of collocated operating bases COBs gains even more importance when considering that:

(1) ROK units "host" DoD functions at these locations, although certain areas and facilities are still operated and maintained by DoD. According to DODI 4715.8, DoD has responsibility to remediate contaminated sites located on "DoD facilities. . . including DoD activities on host-nation installations..." (39:3).

(2) DoD units retained responsibility for operating and maintaining facilities and areas on the COBs for many years prior to their return to the ROK. ROK units now conduct flying operations from the same locations as DoD had done in the recent past, using similar hazardous materials as DoD units employed. Determining the

source and liable party of possible contaminated sites may prove more and more difficult as the years pass.

f. Additional interviews should have been scheduled with DoD personnel at the Pentagon, such as with representatives of individual service components responsible for overseas base closure and technology transfer. Their input may have provided valuable insight.

Despite these shortcomings, information gathered from personal interviews and field observations served the purpose of validating many of the findings from literature as well as providing valuable insight into the DoD hazardous waste site remediation policy decision process, Korean environmental program, and the state-of-the-art in remediation technology available in Korea.

VI. CONCLUSIONS

This thesis effort represents the largest (and only) collection of information on hazardous waste sites on DoD installations in Korea, with particular emphasis on those factors which influence the promulgation of remediation policy. Figure 10 illustrates the major factors influencing remediation policy in Korea. Appendix 5-1 lists the major findings of the thesis.

As both Figure 10 and Appendix 5-1 depict, the primary factors affecting promulgation of effective hazardous waste site remediation policy for DoD installations in Korea are:

- Risk to human health;
- Congressional support for remedial actions overseas;
- Cleanup precedents set in other foreign countries;
- The Korean public's perception of DoD with regard to environmental stewardship;
- Korean environmental law and effectiveness of enforcement; and,
- The effect of hazardous waste sites on wartime capabilities.

This thesis does not quantify the magnitude of influence associated with each factor relative to others; it simply identifies those factors which consistently surfaced during a search of historical literature, personal interviews, and field observations of both the DoD

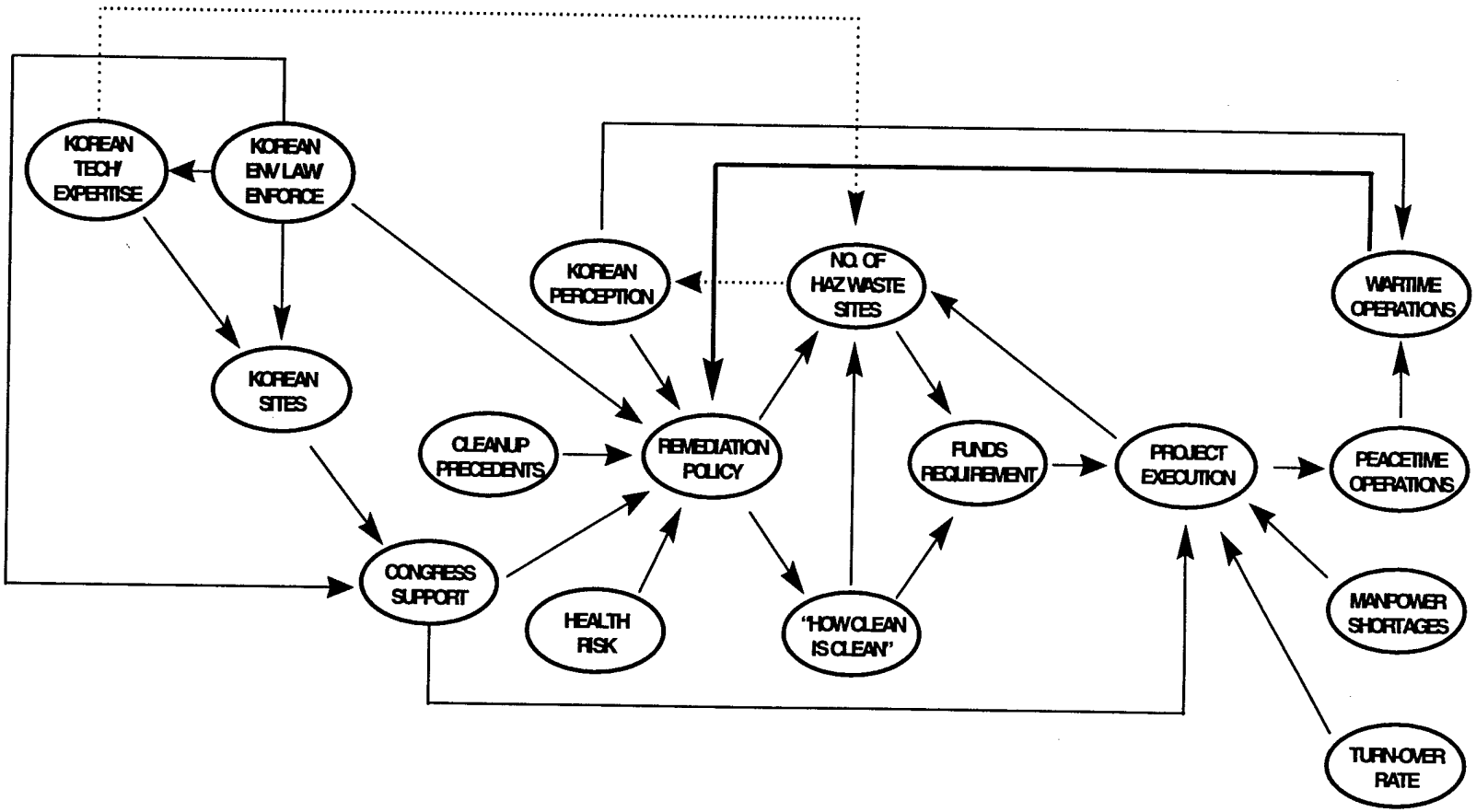

Figure 9: DoD Hazardous Waste Site Remediation Issues in Korea Relationship Diagram

(Line types added to distinguish paths of influence only; no other significance intended)

and ROK communities. It is up to policy making organizations, such as DUSD(ES) and USFK, to take the information provided and apply the findings as necessary for supporting national policy objectives and mission goals.

USFK shoulders the responsibility of developing environmental governing standards based on the unique requirements of Korean environmental law balanced with mission-specific operational requirements and the OEBGD (40:3). USFK has met this requirement in nearly all aspects of environmental concern, except for providing clear guidance on remedial action of contaminated sites due to past and current DoD operations. The absence of a specific definition of "imminent and substantial endangerment" opens the door to considerable interpretation of remediation policy, which could result in wasted resources and diverse environmental conditions at installations throughout the peninsula.

Although resources for accomplishing remedial action are sourced from service-specific budgets (the Air Force funds cleanup at Air Force installations, Army funds cleanup at Army installations, etc.), misalignment of funds due to differing opinions regarding remediation among service heads may result in overall degradation of *joint* warfighting capability in Korea—a USFK responsibility. Individual services, or installation commanders for that matter, may expend funds toward cleaning up a site beyond what is truly necessary to support the mission (taking away resources from other priority projects), or allow serious degradation of the environment to a point which could affect contingency operations (i.e., groundwater well contamination at several MOBs and the COBs). The lack of personnel continuity and experience, owing to a one-year remote

assignment for the majority of personnel assigned to installations in Korea, will likely continue leading to military members making important environmental decisions with little or no training or experience.

Differing budget and manpower strategies among the different services also affect the decision-making process of individual service commanders. For example, Kunsan Air Base, which supports 3 million square feet of facility space, has eight personnel assigned to their environmental staff and manages an annual budget over $3 million (FY97 figures) (7). EUSA, with a total of 82 installations spread throughout the peninsula and responsibility for supporting nearly 26 million square feet of facility space, has a combined total of 42 personnel assigned to environmental functions at the headquarters and installation-level, and manages an annual environmental budget of about $16 million (89). Per square foot, EUSA spends forty percent less in the environmental arena than one Air Force base, and averages less than one environmental person assigned per installation. Although desolate training areas and remote posts make up a large percentage of EUSA's installations, Camp Carroll, which houses EUSA's depot-level vehicle and heavy equipment maintenance activity and the Army's logistics center for the entire peninsula, has only one person assigned to environmental duties.

This review of factors affecting environmental policy in Korea highlights a possible weakness in the existing DoD remediation policy, namely the absence of a definitive, clearly-stated standard governing identification and restoration of contaminated sites. USFK has taken steps toward establishing firm guidance. However, the current guidance does not mention a critical aspect in remedial policy—determining

the risk tolerance associated with a contaminated site. Without knowing the point at which the risk of either (1) acute illness or long-term disease caused by hazardous substances in the subsurface; or (2) future liability due to unsatisfactory past cleanup practices becomes unacceptable to decision-makers, installations and commanders cannot decide when to undertake remedial action, nor when to stop remedial action once begun.

Given these limitations and the possibility of significant mission degradation, more research in this area should be undertaken to clearly understand the ramifications of DoD hazardous waste site remediation policy for South Korea.

1. Optimization of Remediation Policy. This thesis put forward a number of issues affecting remediation policy for Korea; however, no "weights", or priorities were assigned. Starting with the results of this thesis, future research could estimate the relative values policy makers would assign to each factor relative to the others; apply decision analysis and optimization techniques, and compare findings with the current policy to determine how well it compares to the "optimal" policy. Political considerations, national security objectives and priorities, and budgetary constraints all play a large role in establishing international policy. Such considerations must be duly recognized and incorporated into the decision-making process prior to establishing comprehensive remediation guidance for DoD organizations operating in Korea.

2. Country Comparisons. Cleanup precedents in other foreign countries were mentioned in this research as a potential factor influencing remediation policy for Korea. A limited examination of remedial action undertaken in Germany and Canada was accomplished as part of this thesis. However, additional study could be accomplished to

increase comprehension of the legal aspects which affected cleanup liabilities in other foreign countries and determine the extent to which these aspects may affect cleanup policy for Korea.

As demonstrated in this thesis, the environmental awareness of Korea also influenced overseas remediation policy. Hence, a technique to measure the current level of awareness and forecast the rate of growth (or decline) in awareness would aid decision makers in developing effective remediation policy. An investigation of the effects of cultural, political, diplomatic, and other country-unique factors on environmental awareness in other foreign countries, such as Germany (where more empirical data presumably exists) could be accomplished. The results could then be used to develop a model for application in Korea and other countries of interest.

3. Site Characterization and Cost Model Development. Since the scope of contamination at identified hazardous waste sites is unknown, the scope and method of remedial action is unknown. What may seem like an overwhelming and expensive task at first glance may actually be trivial once sites are properly characterized. The prevalent hydrogeology may adequately contain contaminants, reducing and/or eliminating health risk pathways. Microbiological processes may allow natural attenuation to occur, destroying contaminants prior to contacting receptors on or off-base. As highlighted earlier, the lack of in-depth, scientific site assessments at DoD installations makes gauging the severity of the problem extremely difficult. Hence, baseline environmental assessments at all DoD installations should be a top priority for DoD decision-makers prior to considering any remedial action. The Air Force has begun the process by

accomplishing a restoration management action plan at Osan Air Base, followed by a similar process for Kunsan Air Base (174). The plan results from several weeks of intensive interviews, data gathering, and site investigations, and proposes a plan of attack to determine the scope of the remediation problem on the installation (174). Similar studies, at the least, should be planned for other USFK installations.

Related to site characterizations is development of a cost model to estimate cleanup costs for USFK installations based on DoD experience in the United States. The research should primarily focus on two aspects:

- Determination of the most critical hydrogeologic, contaminant, human health risk, and other variables affecting cleanup cost, limiting the number of variables to simplify the model and reduce the costs associated with site-specific data gathering. Examples of such variables include soil type, hydraulic conductivity, sorption coefficient, contaminant type, concentration, and decay rate, receptor populations, contaminant pathways, and future land use (see (73) for a comprehensive discussion of the value of geological, hydrological, and contaminant parameters necessary to characterize a site).
- Application of the model to specific DoD installations in South Korea.

Results from the model would clarify economic issues associated with remediation policy for Korea and aid DUSD(ES), USFK, and Pacific Air Force policy makers in mapping out a future requirements strategy to match cleanup policy.

4. Development of a Cleanup Requirements Strategy and Plan. As mentioned earlier, the organizational structure in Korea makes joint planning, programming, and

budgeting of restoration requirements extremely difficult. The result is "stove-piped" approaches to not only the Korean remediation program, but all overseas remediation programs. Several top-level DoD policy makers offered suggestions for solving the problem, which focused on:

- Creating a requirements strategy (determining the appropriate human and/or ecological health-based risk tolerable for contaminated sites in Korea);
- Collecting requirements (accomplish site surveys at each USFK installation);
- Populate relational database with requirements and available "solutions" (create database of project estimates);
- Apply all solutions to a decision model (prioritize requirements based on decision analysis model as mentioned previously); and,
- Publish a strategic plan, which USFK could use to advocate for resources (in reality, each service may have to advocate for their own resources if funding procedures remain unchanged)

This process for developing a sound investment strategy, which fulfills the funds requirement portion of the relationship diagram in Figure 9, depends critically upon the ability to precisely identify contaminated sites and accurately estimate remediation costs. As mentioned in Chapter 4, the DoD environmental restoration program in the United States (at least the Air Force's program) has been plagued by poor estimates and ever-changing priorities. The result has cast serious Congressional doubt on the validity of the restoration program. As stated by one top-level DoD decision maker, "the future of the entire restoration program depends on the fidelity of project estimates."

To this point, conclusions have focused on weaknesses in the DoD environmental restoration program in Korea; however, an unpredictable Korean future may also affect DoD remediation policy. Although the ROK government has shown signs of their heightened environmental awareness, continued growth in this arena is speculative at best. Korean political history has been characterized by periods of instability and centralized control. With the upcoming presidential elections in December 1997, and the specter of reunification with a poverty-stricken, economically-devastated North Korea looming in the future, sustained emphasis on environmental issues is questionable. On the other hand, remedial issues may come to the forefront should reunification occur, especially given the environmental conditions suspected in North Korea. Articles in Korean newspapers have already compared suspected environmental conditions in North Korea with the West/East German experience at the end of the Cold War. An article in the 5 May 1997 edition of the Chosun Ilbo, a daily Korean newspaper stated:

> We can learn from Germany's experience in cases where the Russian military was based on East German installations. The expenses associated with cleaning up these bases were of the highest category [expense] when compared with other unification expenses. Our government must be generous about investing funds to improve the environmental welfare of our military facilities. Also, we need to pay attention to management of environmental protection and conservation on U.S. military bases. Our government needs to work together with the U.S. . . . (66)

Regardless of the political and scientific uncertainties, proper environmental stewardship should continue to be the rule for DoD organizations in Korea. Recall the quote in Chapter 1 from Ms. Wasserman Goodman (DUSD(ES)):

> We should realize [that] the growing public awareness [of the environment] in Korea will influence our bilateral relationship. Maintaining access to land . . . means we will have to demonstrate integrity in our management of Korea's natural resources. They will look to us as a model. (169)

In particular, the issue of hazardous waste site remediation, which has played such a significant role in the American public's perception of DoD as a steward of public lands in the U.S., is likely to be viewed as important by the citizens of Korea. Therefore, in addition to the negative health effects which contaminated sites may have on personnel, DoD quiescence with regard to hazardous waste sites on DoD installations in Korea may also result in negative perceptions within the Korean populace. These negative perceptions, in turn, can easily lead to loss of access to our Korean base of operations. This is a scenario we can ill afford if we wish to continue maintaining a strong military presence in the East Asian theater, a requirement vital to fulfilling U.S. strategic security interests.

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