6 de julio de 2005

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Estimado Ingeniero Esteban Ramos González,

El presente es nuestro informe que se llama "Valoración Ambiental de Incidentes Químicos". Fue escrito en el Instituto Nacional de Seguros desde el 16 de mayo al 6 de julio de 2005. El trabajo preliminar fue iniciado en Worcester, Massachusetts, antes de llegar a Costa Rica. Estamos emitiendo simultáneamente una copia de este reporte a Profesor Arthur Gerstenfeld y una copia a Profesora Susan Vernon-Gerstenfeld para la evaluación. Después de la revisión por la facultad, la copia original de este reporte se catalogará en la Biblioteca Gordón en Worcester Polytechnic Institute. Le agradecemos el tiempo que usted y el resto de personal en el Departamento de Ingeniería nos han dedicado.

Muy atentamente,

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ENVIRONMENTAL ASSESSMENT OF CHEMICAL INCIDENTS

(July 6, 2005)

This project is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of El Cuerpo de Bomberos of Costa Rica or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

ABSTRACT

The goal of this project, conducted for El Cuerpo de Bomberos, the national fire department of Costa Rica, was to promote understanding and responsibility for the effects that chemical disasters have on the environment. We created TEEICI, Tool for Evaluating the Environmental Impact of Chemical Incidents, to quantify the environmental damage done by hazardous materials. The program is to be used for communicating to the Environmental Tribunal of Costa Rica the extent of the environmental impact caused by polluters. During our studies of many chemical disasters, we also formulated recommendations that would reduce the frequency of chemical incidents and better improve emergency response.

AUTHORSHIP PAGE

As confirmed by the signatures below, every section of this report is comprised of the collaborative effort from Parth Bhuptani, Joshua Strauss, and April Vaillancourt. All three students have actively and equally participated in the creation, development, and proofreading of each section.

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EXECUTIVE SUMMARY

Each year, over two hundred incidents involving hazardous chemicals occur in Costa Rica but their effects on the environment are unknown. In order to study the damage caused by these events, we have created an easy-to-use evaluation package: Tool for Evaluating Environmental Impact of Chemical Incidents (TEEICI). El Cuerpo de Bomberos, the national fire department, will use this system to communicate the severity of each incident to the judicial system. Additionally, to explore the associated consequences to humans, we have created a subcomponent of TEEICI: Human and Economic Ramification Tool (HERT). With the aid of these tools, we expect to raise awareness of the level of damage being done by dangerous substances to the environment.

The Bomberos, a division of the Instituto Nacional de Seguros1 (INS), safeguards four million Costa Ricans from a wide range of manmade and natural disasters. These events include gasoline spills, ammonia leaks, chemical explosions, as well as a variety of other accidents. At times, industries recklessly pollute the environment because they are not charged with the remediation. Consequently, the Costa Rican people and the environment must pay the penalty instead. The Bomberos recognize that by knowing more about the impacts these accidents have on the environment, they will not only be able to better prevent future accidents and clean up contaminated sites more efficiently, but also to force polluters to take responsibility for the devastating effects they are imposing on the country.

With over a three percent annual expansion of industries in Costa Rica, these industries are beginning to resemble those found in more developed

[1] National Institute of Securities

nations, leading to an increase in the amounts of hazardous materials present in the country. Unfortunately, as companies have expanded their production to this nation, laws, regulations, enforcement, and knowledge regarding the growing level of hazardous materials have not kept pace with the dangers involved.

The Bomberos are initially in charge of all chemical incident sites and therefore deemed authorities on the subject of past accidents. Due to their extensive involvement, the Environmental Tribunal, held by MINAE2, often summons the Bomberos to testify following an accident. However, there is currently no system in place that determines the risk posed to the environment by chemical accidents. As a result, cases are often dismissed due to inconclusive findings.

Having a practical and unambiguous scale that evaluates the environmental impact caused by chemical accidents is undoubtedly advantageous to Costa Rica on a national scale. Owing to an explicit numerical scale, aspects such as damage to an area of soil, water systems, air quality, or wildlife can be expressed to a wide audience with ease, regardless of its background. For the Bomberos, this means that they can effectively provide higher authorities with a detailed description of consequences. Interested parties include the MINAE, Ministerio de Salud3, Comisión Nacional de Emergencias4, as well as the administrative authorities of INS. TEEICI will be valuable for the Bomberos to use when testifying in court and will assist in holding responsible parties accountable for endangering the people and habitats of the country.

One of the most significant aspects of our project is that once the evaluation system is in place to make on-site environmental assessments, these

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[2] Ministry of Environment and Energy
[3] Ministry of Health
[4] National Commission on Emergencies

reports can be used for any purposes well beyond those involving legal action. TEEICI and HERT allow the Bomberos and other emergency personnel to catalogue all of the consequences of hazardous accidents as they happen. Once the results are compiled, any interested parties in Costa Rica will be able to contact the Bomberos and obtain a listing of all of the damage done categorized by type of accident, type of pollution, or impact. The possibilities for analysis and application of this data are then only limited by the creativity and needs of those concerned. Once analyzed, this data can be used in education and research, most importantly in medical, preventative, and environmental studies. For example, one could study the trends between causes and severity of accidents, and thus identify areas of concern and formulate remedies. It is therefore of great importance that TEEICI is able to record the raw data in an easy-to-understand and accessible format that anyone can use.

In addition to creating an environmental assessment model, we have developed HERT to quantify fiscal damage, which will institute a greater sense of responsibility to companies and industries that use chemicals on a daily basis. For example, the cost of cleaning up the contaminated soil and water could be appraised and the responsible company would be obligated to pay for decontamination. Furthermore, when people and livestock are killed or injured, those accountable could be obligated to compensate the victims and their families.

To create TEEICI and its subcomponent HERT, we personally visited several accident sites in order to study the damage done by various chemicals in different volumes. We conducted research on chemical accident sites that varied from the chemical released to the geographic characteristics of the surrounding areas. At each site, we interviewed as many emergency responders and victims of the incident as possible, in addition to noting any lasting effects on vegetation and animal life.

Once we had a basis for our own evaluation system, we interviewed many experts to obtain their opinions on the viability and validity of the model. The experts that we interviewed came from an array of institutions, including universities, industries, and governmental organizations. In order for assessments based on our model to withstand court proceedings including cross-examination, which would be its primary purpose, we needed to make sure that the model was accurate. Although we incorporated as many expert opinions as possible, the system still requires further testing.

TEEICI also has the capability to correlate the level of damage done to the rate at which nature will recover. The eight weeks we spent making and testing this model did not offer enough time to analyze soil and water samples from accident sites. Given this limitation, we could not verify if the model was accurate predicting the length of time for full recovery in soil, water, air, and plant life. A future project could determine TEEICI's level of accuracy, as well as make calibrations to increase precision.

The nature of our research lent itself to gathering information from multiple governmental organizations. Unfortunately, Costa Rica's ministries often lack communication, primarily because there is neither a coordinated data collection effort, nor a central system in place to disseminate information effectively. In the future, these problems could be remedied by establishing data collection coordination and then optimizing communication. It would also be beneficial to create a centralized database that stores TEEICI data, along with all other data collected by individual ministries at accident sites, undoubtedly simplifying the process of analyzing chemical accidents.

There are few places left in the world where humans have not fouled their own nest. Because of the ecological consciousness of Costa Rica, thirty percent of the country remains as protected natural reserves, which are home to hundreds of rare species, some of which are in danger of extinction or cannot be found anywhere else in the world. With the help of TEEICI, the Bomberos can illustrate to the rest of the country what the impact of industrialization continues to be on the environment. When the level of this damage becomes clear, polluters will be forced to take responsibility for the destruction of Costa Rica's natural habitats. Consequently, there will be a reduction in the number of accidents that occur, ensuring the wellbeing of Costa Rica's habitats for years to come.

The people of Costa Rica will benefit immensely from a reduction in chemical accidents. Death, injury, and sickness caused by chemicals will be reduced greatly, and it will be safer to live near highways or chemical plants. This will also help farmers protect their crops and livestock, which are vital to the health of the population, from the devastating effects of chemical spills. In addition to the aforementioned benefits, Costa Rica profits financially by maintaining a healthy environment, since sixty percent of the economy depends on ecotourism. It would be difficult to find anyone in Costa Rica who would not be benefited by a thorough study of the chemical effects on the environment. We are confident that TEEICI will serve the Bomberos and other branches of the Costa Rican government as the basis for evaluating the impact of chemical incidents in forthcoming years. Within the recommendations we have made, there lies great potential for improvement. This can be realized with WPI's continuing cooperation with the Costa Rican government for the development of the nation.

Chapter I: INTRODUCTION

Most of the industries that people in modern society depend on utilize a variety of chemicals that must be stored and transported around the world. There is an inherent health and environmental risk in using, shipping, and storing these materials. Many of them are dangerous to people and other organisms, especially when concentrated in one area. Events such as accidental spills and disregard for handling regulations (U. S. Department of Transportation, 2005) result in degradation of the environment and consequences to its inhabitants. Despite the amount of care exercised in safeguarding these materials, past events have shown that accidents are inevitable.

On November 3, 2004 at a chemical plant in Cartago, Costa Rica, the valve for a massive storage tank containing 40,000 liters of super gasoline malfunctioned even though all due care was taken in the handling process. As a result, the chemical plant was evacuated, and a nearby coffee plantation was filled with gasoline, destroying the crops (see Appendix Q). Considering the consequences of that accident, similar incidents must be dealt with in an appropriate and rapid manner, and it is therefore necessary that emergency personnel be adequately prepared to respond to such catastrophes.

In an ideal situation, all chemicals would be produced and transported safely and none would leak into the environment and cause damage. This is usually the case, and a majority of chemicals reach their destination without incident (Spitz, 2003). Unfortunately, no method devised to store chemicals is flawless. Equipment will sometimes fail and individuals responsible for chemicals do not always do their jobs properly, making a contingency plan necessary to handle situations deviating from ideality.

A precise and prompt response would ensure a reduction in the immediate damage and would lead to a better long-term outcome. In an attempt to ensure minimal incident rates, standard operations call for constant monitoring and maintenance of everything from storage units and chemical production plants, to pipelines and transportation vehicles.

Successful day-to-day operations are not reported on the news because they are typical and uninteresting. However, when these basic procedures are not followed, disasters occur, becoming newsworthy events. For instance, on June 13, 2002, a five hundred-pound tank leaked chlorine gas into the environment at an industrial plant in Cartago, Costa Rica (see Appendix Q).

Due to the gaseous nature of chlorine at these conditions, the firefighters could only wait for the chlorine to dissipate into the air. Even though the firefighters were successful in closing the valve in a timely manner, over a thousand people had respiratory problems and had to be hospitalized in neighboring areas, as far as San Pedro and Guadalupe. This was because the wind had shifted the cloud of gas in the direction of the settlements, and there was no way to contain it. A chlorine leak such as this is potentially dangerous to human life, as well as detrimental to any ecosystems with which it may come in contact.

When an accident such as this occurs, authorities such as the Ministerio de Salud, as well as the Environmental Tribunal held by MINAE are very interested in learning the extent of the environmental impact. The Environmental Tribunal is responsible for prosecuting those damaging the natural environment of Costa Rica. On average, two hundred chemical accidents occur annually in Costa Rica (Appendix Q), yet there was no system in place to determine the damage to the environment. Most accidents are never completely cleaned up, and chemicals are left to be absorbed into the soil and water, which in turn harshly affect plant, animal, and human life. The Bomberos are very concerned about this lack of information and thus needed an efficient method to evaluate the damage caused to the environment, and clearly communicate the extent of damage to higher authorities.

Our primary goal was to promote understanding and responsibility for the impact of chemical incidents on the natural environment for the Bomberos, as well as the general population of Costa Rica. This was accomplished by our objective to create an easy-to-use on-site evaluation system, TEEICI, for use by the Bomberos immediately after an accident has occurred. This system is comprised of a numerical scale that individually takes into account the damage to soil, water, air, flora, fauna, and human life. At an accident site, once the necessary information has been determined, Bomberos can fill out the evaluation system, and an overall numerical impact level can be assigned to the incident as a whole. By using quantitative descriptors, this information can be communicated easily to any interested parties, as shown in Appendix C and E.

To accomplish our primary goal, we investigated past chemical accident sites around the country where we calibrated a working scale to accurately reflect the environmental damage. We based our collection techniques on advice given to us from Ana Lorena Arías of Surá Soluciones Ambiental, an environmental engineer and expert in environmental assessments (Appendix G). With the necessary information collected, we fine-tuned our evaluation system to be as accurate as possible. After having created this tool, we evaluated its validity against real-life situations.

Chapter II: LITERATURE REVIEW

2.0 Reader's Guide to the Literature Review

This chapter provides background information specific to our project resulting from research our group conducted. Its purpose is to introduce vital information regarding chemical spills and their environmental effects. This chapter begins by characterizing various hazardous materials and continues to describe the damage caused by their release onto the environment.

2.1 Chemical Damage

April 11, 2003, played a pivotal role in making Costa Rica aware of the dangers accompanying chemicals, when one of the nation's worst chemical disasters occurred. An enormous paint factory erupted into flames, as can be seen in figure one. The fire was caused by static electricity underneath an elevator shaft igniting nearby paint. Many people were

Figure 1: Explosion at Pinturasur Factory

injured in this accident but an unforeseen danger spread far away from the initial accident site (Appendix Q).

Nearby to the paint factory flows the Río Torres (Torres River) that many of the poorer communities in San José without running water primarily use. Those without radios or televisions were caught off guard of the impending disaster, and many people drank the water, unaware of its dangers. Along with the many people affected by this disaster, hundreds of fish died as a result, further illustrating the extensive environmental damage.

Visible signs of paint in the river did not clear for weeks. Despite the best efforts of the Bomberos and other emergency personnel doing all they could to contain the spill with dikes, the paint from the enormous factory relentlessly continued seeping into the nearby drainage system. Days later, when the last of the paint ceased trickling into the nearby river, the water was still not fit for drinking. Some residents developed illnesses with symptoms such as nausea.

Over two years have passed since the accident and paint still covers the rocks all around the river. Nature will slowly clean the water and rocks as time proceeds, but the long-term effects are severe. Although the river is now filled with fish and residents are drinking the water once again, the scars left by the accident will take a very long time to heal. This is typical of chemical accidents; the damage caused does not heal for years after the incident.

In this particular case, those at fault for the accident were never held accountable. To prove that paint did contaminate the river, the Bomberos took water samples downstream of the spill. The results were not surprising, showing high levels of paint contamination. When the case reached the environmental tribunal, the owners faced many fines and penalties for the environmental effects that the spill had. To the surprise of the Bomberos, the owners argued that the river was contaminated prior to the accident. The Bomberos had not taken samples upstream of the accident to serve as a control sample, and the case was closed without any parties held accountable.

2.2 Studying Chemicals

The environment provides a habitat that allows living organisms to flourish. In the natural world, changes often occur slowly enough to allow species to adapt and survive. For millions of years, nature has maintained a balance in which plant and animal populations can be sustained. Since industrialization, the rate that humanity has been disturbing this state of equilibrium has increased alarmingly, and chemicals have played an enormous role in nature's degradation.

For our purposes the term chemical will be defined as, "human-made or synthetic compounds—or not of natural origin," (Merriam-Webster, 2004). With the rise of chemical production, huge arrays of processes and industries have been allowed to develop and flourish. Chemical production is needed for just about every industry, such as in fuels, plastics, clothing, or sanitization. However, chemicals pose a unique risk to the natural world because of the irreversible effect that they have on ecosystems. Compared to the damage done by natural disasters such as floods or earthquakes from which the earth adjusts relatively quickly, chemical damage can last for centuries or even be permanent (Moore, 1997).

Whether contamination will remain at a chemical accident site for long periods of time depends on many factors. Every type of hazardous substance behaves differently and consequently is important to use a variety of analytic methods in order to paint a complete picture of an accident. Some chemicals will stay in the soil for long periods, but often sink deeper into the soil as time goes on. Others will be evident only in biological pathways, such as discolored vegetation or contaminated fish. Still others will be washed away by the rain in a relatively short amount of time and may leave no long-term indicators for study. Therefore, depending on how much time has passed since the accident, respective tests can be carried out. For instance, one may generally not find testing water from rivers beneficial after two years unless the chemical was harsh enough to leave its remnants.

In a contaminated river, it is important to study the condition upstream from the spill area and contrast it with the conditions further downstream. Perhaps the water will be very discolored and murky where contamination has taken place and relatively clear elsewhere. The moss growing on the rocks will also indicate the presence of contaminants by its color – green if clean, brown or black if poisoned. Plants growing along the river can also be a valuable signal, as contaminated areas will have less or unhealthy vegetation. This is a condition visible by discoloration, yellow or brown instead of green or perhaps minimal or stunted growth in the area of contamination. Nevertheless, sampling may not provide sufficient information about the accident (see Appendices G and H).

Damage to animal populations is hard to determine. A large presence of small red worms in the soil is one perceptible indicator suggesting contamination. Apart from this, it is very difficult to count wild animals that may be affected as they often flee the area, and are difficult to keep track of given their natural tendency to stay hidden.

2.3 Costa Rica's Chemicals

The economy in Costa Rica, like many countries, relies on chemical production. Traditionally, most of the production in Costa Rica has been focused on produce due to its favorable climatic conditions. By the 1980s, most of the production in Costa Rica was based on coffee and bananas (Fodor, 2005). However, the 1990s brought many new businesses to Costa Rica, including Dell, Motorola, and Intel. By 1994, nineteen percent of production was chemicals, rubber, and plastics, fifty to seventy-five percent of which was exported (Lara, 1995). Having access to two oceans makes this country economically attractive, and therefore appealing to relocate to Costa Rica. By 2003, Intel alone represented thirty-seven percent of exports (Fodor, 2005). This is representative of Costa Rica's industrial growth and prospective future as a fertile land for multinational investors.

Despite Costa Rica's small size, it is the site of twelve chemical production companies (http://www.1costaricalink.com, 2004). Chemicals that are used in food products, such as acetic acid, citric acid, and ascorbic soda, are produced by El Grupo Transmerquim (http://www.transmerquim.com), a conglomerate of industries in Latin America. Other chemicals are used in agriculture, such as potassium nitrate. In 1999 alone, the manufacturing output of chemical products in Costa Rica netted $168 million, while the industrial chemicals sector netted $136 million, of which up to twenty-six percent was exported (http://www.costarica.com). The Bomberos have suggested further investigation into the environmental impacts of chlorine, ammonia, and LPG due to the frequency of accidents involving these chemicals. Due to extensive applications of these chemicals, there is a realistic probability that mishaps involving these particular substances may occur.

As vital as these substances are to maintaining human society, they can also be extremely hazardous to human life and to the environment as a whole. Chlorine gas, although used in sanitation, is deadly in large concentrations. This chemical was used as a weapon in WW I because a breath of air containing one thousand ppm[5] can be lethal to humans (Burke, Robert. 2003). Chlorine is two and a half times heavier than air, and therefore stays close to the ground, further reducing chances of survival (US Department of Transport, 2004). Chorine gas has myriad applications in pharmaceuticals, agrochemicals, solvents, and polymer production, to name a few. Given the wide range of uses, chemicals are

[5] parts per million

transported in large quantities around the world. There are other commonly used chemicals that are worrisome for the environment besides chlorine, such as ammonia and LPG.

Ammonia can be poisonous to living organisms, especially aquatic life that absorb it directly through the water that they live in (Vosjoli, 1992). Due to the highly combustible characteristics of LPG and other fuels, there is a high risk of explosion in storage and transportation. Mishaps involving flammable chemicals can result in a massive loss of life. As seen in the previously mentioned example of chlorine gas escape, environmental damage is extremely severe and may last for indefinite periods.

The transportation of commonly used hazardous chemicals is vital to the economy and industry. Given its wide presence in the transportation stream, and the safety and security issues surrounding these activities, it is necessary that transportation laws and regulations be mandated in order to protect the public, facilitate compliance, and provide for the efficient movement of these essential materials.

Unfortunately, traffic laws are not strictly enforced in Costa Rica, which often lead to disregard of transportation safety and subsequently, accidents. Most imported material is transported in tankers from the ports to the major cities. Given Costa Rica’s mountainous topography, the routes taken by these trucks are often narrow, winding, and steep—conditions which tend to increase the risk of accidents. In addition to this, truck drivers often drive at high speeds in order to boost productivity. Although all tankers are required by law to be clearly placarded, many do not declare their contents. This is dangerous because in case of an accident, the Bomberos would not know what kind of chemical they are dealing with, prolonging efficient response and appropriate cleanup. Therefore, strict regulation and enforcement of laws would prove beneficial to the environment.

2.4 Chemical Spills

Despite the great care exercised, accidents are inevitable and should thus be anticipated. There is sufficient rationale behind why chlorine was specifically pointed out as a hazard by the Bomberos in Costa Rica. Chlorine's hazardous nature is illustrated by the August 2002 accident in a Missouri chlorine repackaging plant, where equipment failure led to the release of over 48,000 lbs of chlorine gas. According to a report by the U.S. Chemical Safety and Hazard Investigation Board (US CSB, 2002), the impact of the accident not only led to loss of life, but also widespread environmental damage. Several people suffered inhalation related injuries, but most were evacuated before being exposed. As the cloud of gas dissipated, everyone living in the path of the cloud had to be evacuated to avoid exposure.

This leak had a lasting effect on the area surrounding the plant. Nearly seventy percent of all chemical spills find a way to contaminate fresh water (Smith, 1981). The local environment was devastated. Plant life that came in contact with the cloud turned brown for a full year until new growth replaced the damaged plant matter (Investigation Digest, 2002). Were this repacking plant situated near agricultural lands, a huge risk of soil and crop contamination would have to be considered. Gaseous leaks are very difficult to contain (Smith, 1981), and the only way to safeguard against them is to have an effective contingency plan, including adequate evacuation systems. Even though contingency plans may save human life, the effect of chemicals on the environment still remains irreversibly destructive.

Chlorine's hazardous nature is further illustrated by the November 5, 2002, accident in Las Juntas, Costa Rica (Appendix Q). At a water treatment plant, a valve malfunctioned, releasing chlorine gas from a storage tank into the atmosphere. The Bomberos quickly arrived to the accident scene, but because the valve was different from anything they had seen before, they accidentally opened the valve further in an effort to close it. The impact of the accident not only led to loss of life, but also widespread environmental damage. Several people suffered inhalation related injuries, but were evacuated before being exposed. Everyone living in the path of the cloud of gas as it dissipated had to be evacuated to avoid exposure.

The above is an example of a situation where the fire department was not prepared to deal with an emergency of such type and magnitude. This is particularly relevant to Costa Rica, since according to Esteban Rámos, head of the engineering department for Bomberos, lack of adequate training is one of the causes of incident mismanagement. In the Las Juntas plant, even though the emergency shutdown system was activated, a malfunction occurred because some of the valves did not close within the required time. It took emergency responder personnel hours to safely get through the dense cloud of chlorine gas in the proper suits and shut off the system manually. No evacuation procedure was set in place for the surrounding area. After further investigation, the Bomberos determined that the accident was caused by corrosion in the tank, and not in the valve.

The environmental impact of the chlorine leak was severe. The chlorine that settled to the ground killed the plant life instantly. The smaller vegetation has since recovered from the chemical leak, whereas larger trees were still visibly damaged. Residents also reported no other lasting effects from this spill on the environment.

Fuels are volatile materials due to their inherent flammability. This makes substances such as propane gas very hazardous to transport and store. Mishaps lead to large fires, explosions, and often death. In the event of a leak, propane gas contaminates the surrounding communities as well as the soil. Its combustion with oxygen in the air also adds to atmospheric pollution.

In February 2003, a chemical plant in Alajuela Central, Costa Rica, caught fire (Appendix Q). Leaking gasses such as propane, ignited, spreading the inferno. As the fire worsened, pipelines carrying ammonia decayed and deadly levels of ammonia leaked. The environmental contamination in this case was extensive to the immediate area, but fortunately, there was no nearby water source. Nevertheless, the soil underneath the leak was contaminated and required cleanup.

The lack of information regarding location of hazardous materials is also a problem in Costa Rica. On December 5, 2002, a highway construction crew ruptured a gas pipeline while repairing a highway (Appendix Q). Figure 2 shows the punctured gas line as damaged by the crew. The subsequent leak spilled into a nearby ditch, and was guided downhill into the area of a coffee shop. The fire department made every effort to absorb the spill, as well as to shut off the flow through the pipeline. Despite this, an unavoidable amount of contaminants leaked into the environment. The environmental damage done by this accident is yet unknown because there was no system in existence to measure such effects.

Figure 2: Oleoducto (oil pipeline) puncture

Another problem that underlies many fire departments all over the world is improper equipment management. This can lead to catastrophe, as exemplified by the leaking gas pipes of Guadalajara, Mexico. On April 21, 1992, a series of nine explosions rocked the city of Guadalajara, taking out twenty blocks and killing two hundred people (http://www.corrosion-doctors.org/Localized/sewer.htm). This was later determined to be due to corroded gas pipelines that had caused the explosive fumes to leak into the sewer system, and eventually up onto the streets through manhole covers and drains. Evidence suggests that the gas was building up for hours before a spark finally ignited it, blowing a hole into the earth, swallowing buildings and cars, and taking hundreds of civilian lives.

This catastrophe becomes even more tragic when one considers that the local fire department had evidence of the impending disaster. For up to twenty-four hours before the incident, local residents had been complaining of a strange fuel smell, headaches, and stinging throats and eyes. Reports like these are valuable indicators, especially considering that often, local authorities are not so lucky as to have these precursors. However, little was done in response to the complaints and the opportunity to shut off the gas slipped by.

Evidence suggests that the fire department knew there was a leak from an unknown source but did not realize the gravity of the situation. Some witnesses report seeing firefighters lifting manhole covers around the area to allow the gas to escape, suggesting their awareness that gas buildup was dangerous. Had they known the source of the leak, more could have been done, however they were neither aware of the placement nor the condition of the pipeline underneath the street. The warm climate and high humidity were later found to be contributors to the leak. This information may have been useful in preventing the leak in the first place.

Like all fire departments, the one in Guadalajara had to make the best with what was available. While firefighters will undoubtedly do their best to deal with any situations that come up in order to keep local people safe, lack of information or resources can impede their efforts. For economically less developed countries, lack of resources allocated to emergency management represents a risk to the lives of the firefighters and the people they protect, as well as to the environment of the country.

On November 3, 2003 in Cartago, Costa Rica, a storage tank containing forty thousand-liters of super gasoline began leaking (Appendix Q). The cause of the accident was corrosion to the metallic container. The human impact was not very severe, unlike the Guadalajara example, because there were no human populations nearby. However, the entire content of the tank leaked out, causing severe damage to the environment. The tank, situated next to a dense forest, killed over twenty-five square meters of plant life. In addition, a nearby stream filled with gasoline, killing the fish and washing their carcasses up along the shoreline. As seen in Figure 3, much of the vegetation has grown back two years later, but banks in the stream still contain gasoline. The thick smell of gasoline odor remains in the same area where the spill first occurred.

Figure 3: Devastation of vegetation

Similar to many other gasoline spills in Costa Rica, the courts came to no conclusions and thus no one had to pay for the clean up of the spill. Without soil and water samples analyzed by experts, there is no way to be certain that the contents of the tank polluted the surrounding area. With a lack of funds, spills like these are left to linger for long periods.

2.5 Improvements in Disaster Response

When authorities are well informed of the risks in the area, emergency response yields a much more favorable outcome. This is illustrated by the Texas City Fire Department's recent handling of a British Petroleum refinery explosion on March 23, 2005. Given the large number of refineries in the area, the fire department was well prepared to deal with the incident. Although fifteen people are confirmed dead and over a hundred injured, the disaster could have been much worse (Easton, 2005), considering the vast quantities of petroleum processed.

Figure 4: Texas City 1947 Disaster (source: http://www.local1259iaff.org/disaster.html)

The outcome of the 2005 BP explosion was very different compared to a disaster that took place in the same city in 1947, namely because of the contrast in coordination of the emergency response. By the end of the 1947 disaster, 576 people lost their lives and 178 were never found. In 1947, the explosion that started the chain of events was

2,300 tons of ammonium nitrate, or the equivalent of detonating seven hundred tons of TNT (Guidelines for processing hazards, 2003). Figure 4 illustrates the sheer magnitude of this explosion. Considering a one-hour time lapse between the ignition of the fire and the enormous explosion, much could have been done to protect both the firefighters and the residents. Had more information been available regarding the contents of the vessel and its destructive potential for emergency responders, this incident could have possibly been prevented or better contained.

In the 2005 Texas City response, Occupational Safety and Health Administration (OSHA) and the Texas City Fire Department were well aware of the hazards surrounding the petroleum plant. The plant manager of the BP site has stated that he expects the explosion to affect operations by no more than five percent (Reuters, 2005). Considering the explosion did not lead to a chain of events like the prior 1947 incident, personnel involved in emergency response preparations can be commended. Although details of the explosion will take months to unravel, the continuing functionality of the refinery plant is noteworthy.

The accident response in the United States has dramatically improved, as can be seen in the above example. According to Bennet, Feates, and Wilder (1982), prior fire responses consisted of dousing a fire with water. Today's computer systems, widely used by fire departments in the US, help them quickly identify the type of fire at hand and the appropriate response. Today, firefighters have a wide variety of materials for fighting fires including high expansion foam systems.

The Bomberos of Costa Rica have also had significant improvements in their prevention of and response to chemical accidents. In recent years, the number of chemical accidents has been decreasing. In 2003 and 2004, over two hundred chemical accidents occurred in Costa Rica on a yearly basis. Finally, in 2005, Costa Rica had under two hundred chemical accidents. The efforts of the Bomberos in their preventative measures have paid off greatly with increased attention to chemical hazards.

In the United States, commercial transportation of such chemicals is highly regulated by uniform national standards. This has led to a commendable safety record, taking into consideration that millions of tons of material, over 1.2 million times a day, are transported. Unexpectedly, only ten out of 5,900 deaths to workers in America are caused due to hazardous materials (Murthy, 2002).

The Department of Transportation (DOT) enabled the Hazardous Materials Transportation Act (HMTA), which regulates the marking, classifying, manifesting, labeling, packaging, placarding[6], and spill-reporting provisions for hazardous materials in transit (Office of Hazardous Materials Safety, 2005). One of the most important of these is the cargo manifest, or Material Safety Data Sheets about the chemicals being transported. In case of accidents, these are used in order to evaluate the emergency response (US DOT, 2003).

Costa Rica faces many obstacles before the transportation of hazardous materials becomes any safer. Drivers operating trucks containing chemicals do not require special licenses. On top of that, there are no accurate statistics from

[6] Appropriate label identifying hazardous or other types of cargo

the government reporting the number of traffic accidents that occur in Costa Rica annually.

2.6 Benefits of an Evaluation Tool

Currently no quantitative method exists to accurately determine the environmental impact on any given area. Without sufficient information about environmental damage, Costa Rica is left in the dark as to how much damage is being done to its ecosystems every year. Moreover, the absence of this quantitative data makes it difficult to appropriately penalize the responsible parties. Once the courts and the governing bodies fully realize the extent of damage being done, they would be more apt to enforce laws and regulations already in place more strictly. With better enforcement of environmental laws, industries would be forced to reconsider their shipping and storage strategies in order to avoid large fines or other harsh consequences.

An evaluation tool would also serve the purpose of determining whether nature is capable of cleaning itself up. In many cases the Bomberos, lacking extensive cleanup methods, leave chemicals in the ground from accident sites, hoping that nature will be able to fix the problems. This is inappropriate considering the level of damage certain chemicals can have on plant and animal life for years to come. With limited funds, the Bomberos require a simple evaluation tool that can determine whether a certain site requires further attention from environmental experts.

There are many other benefits to having a database of this type of information. For instance, this numerical data can be plotted on a GIS map and used to identify trends in the locations and levels of environmental damage in the country. This information can then be used in education and research of all types, most importantly to conduct medical and environmental studies. The prevention of future accidents can be performed by creating better safety measures or better industrial and commercial planning. Identifying trends can also lead to a better understanding of the long-term health of Costa Rica's environment.

Chapter III: METHODOLOGY

3.0 Introduction to Methodology

To expand the range of services that El Cuerpo de Bomberos provides to the Costa Rican people, the fire department wants to take into account the environmental impact caused by chemical disasters. In order to strengthen this area of expertise, we have focused on establishing a model to determine the impact chemical accidents have on the environment. Along with this objective, we made numerous recommendations to local law enforcement and other officials. We planned to accomplish these objectives in the following three stages:

1. Preliminary data analysis:
    a. Inventory and classify emergencies involving dangerous materials that have occurred in Costa Rica
    b. Establish the cause and other details of each emergency by looking into the type(s) of chemical(s) involved, number of causalities, units of Bomberos or paramedics involved, the economic cost incurred, and several other details
    c. Choose a diverse sampling of five accident sites varying in chemical type and land use including agriculture, industrial, and transportation.
    d. Research laws regarding chemical handling and transportation

2. Field Work
    a. Create an initial quantitative model as a basis for our final product
    b. Record any visible environmental degradation at the chosen accident sites
    c. Take soil, water, and air samples at these places
    d. Conduct interviews from relevant sources in the area
    e. Quantify the level of damage caused to the environment by these events
3. Final analysis from field work
    a. Create a working quantitative model based on an algorithm that evaluates environmental damage
    b. Demonstrate methods to prevent future chemical accidents

We were unable to fulfill all of the abovementioned objectives, and the reasons behind the changes in our project can be found later in this chapter.

3.1 Preliminary Data Analysis

The Bomberos already have raw data detailing past emergencies that have occurred in the country. This data includes facts surrounding each accident and subsequent emergency operations, such as the number of firefighters at the scene, the number of casualties, the types and quantities of chemicals present, and a timeline of the disaster. We focused our research on accidents that occurred between 2002 and June 2005 in order to obtain the most recent and accurate information possible. From the information recorded by the Oficina de Comunicaciones[7] (OCO) in Tibás, we were able to gather data about the total number of chemical accidents that take place annually, as well as determine trends that exist within these events. To reveal trends in accidents, we divided them by cause, such as leaks, gas escapes, or mechanical malfunctions to name a few. We were provided with a short summary of all of the significant accidents that occurred each year by OCO, and together with the Bomberos, we chose from this list eighteen of the more serious and diverse accidents to study in more detail. Our criteria for selecting these accidents were a wide range of chemicals involved, different geographic areas, and various causes for the accident. Finally, we reduced this list to group of ten accidents that we could visit and study in depth with the help of the Bomberos. See Appendix P for the map of the accidents.

The final sampling of accidents was chosen based on several factors. It was very important that we chose accidents that were large enough to have had a significant impact on the surrounding environment so that there would be remaining evidence of this degradation available for study. We also tried to include at least one accident from each year of study in order to compensate for changes in environmental conditions over time. By including the variable of time in our analysis, not only could we project how much original damage there may have been in an area, but we were also able to better understand the long-term

[7] Office of Communications

effects of chemical contamination. The most important criterion in our selection of accidents was to be sure that there was a representative accident for each type of chemical that we had encountered in the database. For instance, we planned to include at least one accident for each of the following substances: chlorine, LPG, ammonia, petroleum products, agrochemicals, and less common substances such as paint. Finally, we chose accident sites that were dispersed around the country, considering Costa Rica is very diverse in its topography and ecology. See Table 1 for further detailed information on each of the accidents.

Table 1: Accidents by Location, Dates, and Further Information

Location	Date	Chemicals Involved	Quantity of Chemical	Deaths	Injuries
Limón	Dec 8, 2004	Bunker	9,000 liters	0	3
Zona Sur	Aug 21, 2004	Gasoline and Diesel	9,040 liters of gasoline and 21,590 liters of diesel	0	0
Guanacaste	Feb 29, 2004	Pesticide	n/a	0	0
Alajuela	Oct 19, 2003	Ammonia	n/a	0	5
Alajuela	Feb 21, 2003	Ammonia	n/a	0	48
Heredia	Dec 5, 2002	Combustible Gas pipeline	n/a	n/a	n/a
Uruca	Apr 11, 2002	Paint	n/a – but known to be large quantity	n/a	n/a
Cartago	Jun 13, 2002	Chlorine	500 lbs	0	1,000
Limón	Jun 15, 2002	Combustible hydrocarbons	15,000 gallons	4	n/a

3.2 Fieldwork

Once we had chosen the appropriate cases for further development, we began deciding how to assess the environmental damage in each place. This knowledge was obtained by interviewing several local environmental experts, including Professor Eduardo Rivera from the University of Costa Rica (UCR); Ing. Álvaro Coto Rojas (Appendix J), an environmental engineer at RECOPE (Refinería Costarricense Petróleo[8]); Lic. Ana Lorena Arías of Surá (Appendix G), as well as several professors from WPI.

After our initial observations of the accident sites, we took several soil and water samples. We took multiple samples in different areas in order to compensate for any contaminants that would already be present in the water prior to the catastrophe. We took a sample upstream from the accident to use as a control, while another was taken at the exact location of the spill to obtain the highest concentration of toxins. We took at least one sample approximately twenty meters downstream from the accident in order to study how far the substance had traveled. In areas where there was a lot of contamination, we took a second sample a hundred meters downstream for comparison (Appendix B).

In order to avoid inaccuracies in sample collection, we extensively discussed with Lic. Ana Lorena Arías to find out exactly how soil and water

[8] Costa Rican Petroleum Refinery

samples should be collected. More information about these standard procedures can be found in Appendix G.

The exact number and collection sites of samples cannot be determined unless several tests and return trips to the site are possible. Since we could only visit each site for one day, we made an educated guess to determine from where our soil samples should be taken based on the biological indicators that we could observe. The indicators we commonly searched for were concentrations of dead trees and bushes. In order to determine the affected area, we tried to take at least one sample from outside of the area of the contamination radius as a control sample.

We took soil samples by digging into the ground approximately twenty centimeters, since contaminants usually sink down with time. In areas where the ground was harder and rockier, we dug shallower pits for testing. Where the soil was loose and contained more clay, materials are more likely to sink deeper and therefore, our sampling pit was deeper. In order to obtain the best sample possible, the area of the pit was twenty square centimeters. We sealed the soil samples in plastic bags and gave them to the Bomberos to send to the lab for analysis.

Unfortunately, lab tests on soil and water were not only very expensive, but also time consuming, limiting our study of this portion. Therefore, we collected samples only at the first few sites that we visited, hoping this would give us a good idea of how much detectable contamination remains in an area after an accident has occurred. We, however, never received the results of these samples due to the reasons mentioned above.

When dealing with toxic substances, it was important to exercise several safety measures. Everyone at the site was required to wear boots to protect their feet, and gloves on their hands. In areas of heavy contamination, we also wore masks over our mouths. For extra safety, we wore long pants while walking around accident scenes, and were careful of where we stepped in order to avoid permeating our clothing with contaminated mud.

Given the self-recovering nature of the environment, we were often unable to find adequate clues at the sites. As a result, our interviews with the victims, local fire, police personnel, and medical expert interviews were important in our accident scene analysis. We also interviewed local environmental specialists, as well as officials from the Ministerio de Salud, and MAG if relevant to the accident. These are the people that we felt would be most knowledgeable about the incidents. We also approached them if they were mentioned in the OCO detailed incident reports.

From these people, we obtained a description of the accident and the immediate effects to the people exposed to the hazard. This was especially important in the case of atmospheric contamination, for instance by chlorine, as most of the substance is dispersed rapidly and will not be available to study after the accident. A complete transcript of these interviews is shown in Appendix O.

3.3 Analysis of Fieldwork

To perform a clear analysis of the results, we studied specific aspects such as soil and water contamination, and then compared them together to give us a bigger picture of the damage done to the area. The accidents at the sites that we visited occurred months or years before our arrival, however, TEEICI is designed to evaluate chemical accidents soon after they occur (see Appendix E). Because chemicals break down over time, we had to take into account the amount of time that had passed between the accident and moment of study. Other considerations included possible sources of error such as faulty sampling techniques, miscommunication, or other nearby sources of contamination.

As part of an initial evaluation, we qualitatively ranked soil and water contamination and used them as a basis to compare all the different accidents. This process is later discussed in § 3.6 Value-Weighting Process.

From these results, we were able to contrast areas of high impact with other areas that were relatively unaffected. This analysis in turn was then the basis for our numerical scaling system. It helped us set the higher and lower margins for our scale, as well as a general qualitative description for the different levels of damage (See § 3.6 Value-Weighting Process).

We concluded that an accurate environmental assessment tool would be heavily dependent upon the type of chemical and the quantity released. We used an EPA scale (Appendix R) that rated each chemical in terms of its severity.

We also took into account qualitative analyses such as observation of impact on the water, soil, air, animal life, and vegetation.

3.4 Redefining the Project

After having submitted the samples to the lab and waiting over two weeks without receiving results, we realized that we needed to redefine our project goal and reevaluate our objectives to make them more congruous to the time frame we were given. Even if the samples were analyzed, we would have received the results much too late to be able to adapt them for usage and proper implementation in our model. In addition to the time factor, the total cost for sample analyses for each site would have exceeded $640. Upon further discussion with the Bomberos, we concluded that the price was too high, and not worth the data it offered. Furthermore, we found out that the lab the Bomberos used could not analyze samples containing hydrocarbons—further dissuading us from using samples. A very large part of the chemical incidents that occur in Costa Rica are in some way linked to the spillage of hydrocarbons, and not being able to analyze them would be meaningless. We therefore concluded not to have any soil samples that we collected analyzed. This consequently meant that the soil section in our model would have based on a qualitative analysis.

Another setback we faced was trying to gather further information concerning the accidents we visited from the respective ministries and organizations in San José. This proved to be a huge problem because it involved driving to numerous locations and trying to pinpoint specific information within governmental organizations. Often, interviewing officials in ministries was unproductive because they were unable to offer us relevant information.

This, however, was not the only place where we had problems retrieving information. When we lacked factual information from authorities, we had to depend on information from the victims, which was sometimes inaccurate or biased. Occasionally, people would refuse to give us any information regarding the incident.

As a result, we had to formulate our model based on the limited amount of information we had. Nevertheless, we were able to produce a functional model that can be applied to future incidents with an operative level of validity.

3.5 Analyzing and Formulating the New Model

The list of methodologies that can be used to measure the environmental impact is rather extensive, and each one can be developed into as much detail as resources may allow. In our particular case, the main limitations were time, amount of information available, and often, finances. Nevertheless, with the help of experts, we were able to develop a functional model of TEEICI.

In order to develop a successful model, it was necessary to take into consideration a series of factors to ensure that the final product was suited to the main cause—transmitting environmental impact data efficiently to authorities that may not be familiar with technicalities concerning environmental engineering or the accident. Firstly, we questioned whether the analysis methods had the capability of covering the wide range of combinations of variables that the model would have to incorporate. For example, we had to ensure that we dealt with all aspects ranging from the area of soil contamination to the type of precipitation at the time of accident.

Secondly, we had to ensure that the model was selective, and thus, it was important to select and include all pertinent variables and at the same time eliminate those that would not add further relevance to the project. It was also important to eliminate irrelevant elements based on the opinions of experts and their experiences from past fieldwork and not in an arbitrary fashion. We started with a series of the most important factors that the project's impact would have on environmental contamination and its wellbeing; this helped us generate the primary group of indicators. Once we had this group of indicators, we determined and assigned values to them based on their relevance of impact.

In addition, we also had to ensure that the methods used in the model were exclusive. This means that the method was capable of eliminating the common problem of counting certain aspects multiple times due to the interrelated nature of the environment. For example, we can analyze the characteristics of a chemical from several different perspectives: its toxicity to either human health, towards vegetation, or towards fauna; its reactivity with different elements in nature; or that of its residence time in soil, just to mention a few.

Objectivity is another important property that the method must possess. It was fundamental to minimize the subjectivity that we may bring to the project. As non-residents of our sample space, Costa Rica, we were often unaware of local conditions or public sentiment concerning environmental issues. As a result, after interviewing experts as well as talking to locals about the environment, we had to reprioritize and add importance to aspects that we may have deemed less important or vice versa.

The magnitude of finances available, the availability of computers, access to information databases, scientific programs used to model specific circumstances, and access to laboratory testing are some of the important tools necessary for the development of this type of study. However, they are also some of the limiting factors that we had to take into account while creating the model. We had to ensure that we did not include elements in the model that could not be easily measurable without an array of scientific instruments. Consequently, a large part of the evaluation techniques are qualitative and can be carried out without requiring much equipment.

In addition to these limitations, time was one of the most significant factors that we considered in the designing of the product. The Bomberos needed an evaluation tool that they could put to use on-site, and one that did not require analyses of samples in laboratories or further studies. Therefore, even though analyzing soil and water samples would yield more detailed results, the Bomberos merely needed to know the extent of impact the accident had on the environment. We also set threshold limits on the levels of environmental impact, i.e. if the assessment yielded an impact of over seven out of ten, we recommended that the Bomberos carry out further detailed studies on the accident site as well as look into cleanup methods. Accident sites that rated below three out of ten were very likely to recover without the need of human intervention. In conclusion, the results from our model would notify the Bomberos of the level of significance each accident must be given and consequent actions that need to be taken, if any.

3.6 Value-weighting Process

Our scale runs from zero to ten, where zero means no environmental impact, and ten signifies extreme and often irrecoverable damage. The model is divided into two main parts: the base section and additional situational factors that affect the impact. The base section is directly related to two factors, the type of chemical in interest, and the quantity in which it was released. We used a scale from the USEPA that narrows down the classification process based on its chemical properties, its interactions with natural elements such as soil, water, and air, its residence time in the environment after it has been released, as well as disposal information. All these factors combined determine its placement on the X, A, B, C, D scale, where X is the most dangerous chemical, and D, the least. This was greatly helpful because without it, we would have had to classify chemicals ourselves according to some of the abovementioned factors, which would have been a time-consuming and tedious process. The USEPA scale is not only more accurate than what we would have generated, but also more comprehensive, as it lists over 22,000 chemicals and their respective classifications. In addition to the five types of chemicals, we also added other substances frequently used in Costa Rica, and gave them point values. These point values would then be multiplied by another set of values that would be dependant on the quantity of the chemical. The values given are shown in the following Table 2 and 3.

Table 2: Base number calculations for highly toxic chemicals

Type of Chemical		
X → **0.8**		*quantity of chemical (liters)*
A → **0.7**	x	**10**: >1500
		9: 1300 – 1500
		8: 1100 – 1300
		7: 900 – 1100
		6: 700 – 900
		5: 500 – 700
		4: 300 – 500
		3: 100 – 300
		2: <100

Table 3: Base number calculations for moderately toxic chemicals

B → **0.5**

C → **0.3** x <u>*quantity of chemical (liters)*</u>

D → **0.1**

10: >35,000

9: 27,500 – 35,000

8: 20,000 – 27,500

7: 15,000 – 20,000

6: 10,000 – 15,000

5: 7,500 – 1,000

4: 5,000 – 7,500

3: 2,000 – 5,000

2: 500 – 2,000

1: <500

We assigned the following values to the additional substances:

Bunker (combustible) → **0.8**

Gasoline, Diesel, and other hydrocarbons → **0.6**

Organic waste (septic tanks, molasses, etc.) → **0.6**

Since chemicals in category X are the most toxic, we gave them the highest point value. The rest of the chemical types have lower values based on their classification. For instance, Bunker (crude oil #2), a hydrocarbon, has a higher value assigned than gasoline, diesel fuel, and other hydrocarbons due to its augmented danger level. For a complete value-based analysis, see Appendix C.

On the one hand, if five thousand liters of gasoline leaked into the soil, ninety-five percent of it would evaporate within the first twenty-four hours. Bunker, on the other hand, creates a stronger bond with the compounds in the soil. It is also denser than gasoline, meaning it will not evaporate as readily into the air (Appendix J). Organic waste is generally not considered hazardous to the environment; however, when a septic tank containing large amounts of organic waste overturns, the danger level immediately increases. Certain compounds found in organic waste in large quantities are difficult to break down, and lead to the production of noxious fumes that are harmful to vegetation and animals. It is these factors that aided us in appropriately assigning point values to these substances (Appendix H).

The chemical-type value is further modified by the quantity in which it is released. A higher release quantity gains more points due to the higher damage that it would cause. The product of the chemical-type and the quantity released yield the base figure. For example, when 850 liters of a category X chemical is spilled, a base value of $0.8 \times 8 = 6.4$ is generated.

The second part of the model is comprised of all the additional factors that affect the environment after an accident and are specific to each site. This section is further divided into soil type, weather conditions, and effects on water, flora, and fauna. Each one of these sections has a variety of choices that the assessor can choose from, and has different point values. These functions are to be added on to the previous base figure obtained from the type and quantity of chemical.

The type of surface that the chemical spills onto is an important factor to take into consideration due to several reasons. The hardness of a surface will determine how much of the chemical will permeate into the ground and how far it will spread. We do not consider a spill onto a paved surface as severe as on soil because the chemical will not be able to permeate through concrete as much as it would through soil. However, the problem paved surfaces pose is that they increase the area that the chemical spreads out due to runoff. This problem can be further worsened by the presence of rain, in which case the substance can possibly flow until the paved surface ends. This said, the problems associated with soil are a lot more severe. Depending on the substance's density, it will permeate deep into the ground. This has several problems associated with it. Firstly, it will kill all subterranean animal life and may even affect roots of trees. Secondly, it is possible that the chemical may enter an underground water source, contaminating it. This could be particularly dangerous if the water source is used for drinking.

Soil cleanup is very time-consuming, tedious, and expensive. Cleanup can be approached in two ways: the contaminated soil could either be bulldozed and deposited in another area, or the soil could be chemically leached of the hazardous substances. However, the latter requires extensive pumping over long periods of time, and may cost up to seventeen million dollars per hectare for comprehensive cleanup, according to Ing. Álvaro Coto Rojas from RECOPE.

(see Appendix J for interview). The problem could be made worse if the spill took place on sand or a loose type of soil, since the chemical would permeate deeper as well as over a wider area. Therefore, in degree of increasing severity to the environment is sand/loose-soil, moist soil, and least of all, paved surfaces.

Weather conditions play an extremely important role in determining the impact that a chemical may have on the environment. Rain is a significant aspect because it has the capability of spreading the chemical over a larger area and increasing the area of contamination. Therefore, heavy rain is a lot more hazardous to the environment than a drizzle or light rain, and thus carries a higher point value. Heavy rain is also dangerous because there is a possibility that water may react with the chemical, such as sodium (Senese 2005).

In the case of a gas leak, wind plays a similar effect. We found that there were several ways to approach assigning points to such a situation. A gas leak on a windy day would mean that the cloud of gas would be dispersed, reducing the concentration and associated danger. However, it also means that a larger area would be affected once the gas starts to sink, if denser than air. In contrast, if there were no wind, the gas cloud would stay in the area and have more severe effects within that particular zone. After much deliberation, we decided that the effects on the environment would be worse if a larger region were affected, thus assigning more points to high wind speed. Often, a cloud of gas can head towards forests or nature reserves, where they can have devastating effects on the vegetation, soil, animals, and the ecosystem on a whole.

Vegetation can be easily affected by any type of spill or other chemical accidents due to its dependence on the soil quality. Given the large probability of soil being affected in a chemical accident, we decided to add points based on the area of soil contamination. Several ranges from five hundred to two thousand square meters of soil contamination were created, and the larger areas were assigned higher point values, decreasing with lower areas of contamination. In addition, we added points depending on the type of vegetation area affected. More points were given if the vegetation in a natural reserve or primary rainforest was affected, and fewer if it was a secondary forest. Natural reserves and primary forests are extremely important to the ecosystem as well as to the heritage of Costa Rica, and it is therefore only appropriate that any damage done to them be reflected with a high point value. We also added points if plants were burnt or killed immediately after the spill. If the plants died upon instant contact with the chemical, this was a clear indicator of the high toxicity of the substance, as well as demonstrative of the damage that would be done over a longer period with the presence of the chemical.

The vegetation and soil conditions make up an essential part of the dwelling for animals and other fauna present. Costa Rica prides itself in being the habitat of numerous endangered and protected species, and any damage to such populations would be a great loss, justifying the addition of a large number of points. To make our evaluations more precise, we decided to make a distinction between wildlife and domestic animals since they do not live in similar conditions and therefore, cannot react to an accident in the same way. For example, in case of a chemical spill, wildlife will be able to flee the contaminated area to ensure their safety, whereas domestic animals that are kept in an enclosed area do not have the ability of escaping. As a result, we assigned higher points to the death of animals in a non-enclosed area because despite their efforts to escape the hazardous area, the effect was so widespread that they had no chance of survival. Furthermore, we added points if a large number of animals, such as twenty, in a non-enclosed area were killed, since this clearly suggests the widespread and severe nature of the impact.

Chemical spills cause runoff of the substance and there is a very large possibility that it may end up in a body of water. From our research, we observed that a large sum of accidents in Costa Rica are comprised of spills caused by overturned trucks on highways. Given the large number of streams and rivers that flow throughout the country, the probability of water contamination is very high. We believe that contamination of such streams has grave consequences because they merge into rivers, which lead into the ocean. Therefore, every time a spill runs off into a stream, large bodies of water are affected. The vegetation surrounding the streams and rivers are affected as well, and depending on the quantity and type of substance spilled, populations of marine life are destroyed. Here, we took into consideration different speeds at which water may be traveling. Fast-flowing rivers are not as much of a risk as slow-flowing rivers because in the latter case, the chemical has more time to get absorbed into the riverbed and affect the riverbanks. As a result, we gave a stagnant body of water more points than a fast-flowing river. Further points were also added if fish or other organisms were killed.

Since a lot of hazardous material enters the country via seaports on both the Pacific and the Caribbean side, there is a possibility that an accident may occur at these locations, contaminating parts of the sea. However, given a need for a quick assessment, we only implemented basic, qualitative indicators. We added points if any contamination was visible either in the water, on the sand, or other areas surrounding the spill. More points were added if any marine life is killed or damaged. The Caribbean coast is very rich and is home to many protected species such as turtles, dolphins, or coral, and it is essential that in case of any effect on them, their deaths carry a large point value.

Chapter IV: RESULTS AND ANALYSIS

Each incident that we had the opportunity to study taught us something valuable about environmental assessments. By researching in depth as many sites as time and resources allowed, we observed first hand the effects of several different types of accidents. This helped our understanding of major factors that improve or worsen an environmental situation.

With every new case study, we understood a little more about the common causes of accidents involving hazardous materials in Costa Rica. There were a number of consistencies in every case. At each accident site, an expert from the Bomberos or other organization would give the opinion of how to improve the manner in the handling of the accident. Some of these responses were more common than others. After observing the trends that exist between the cause of the accident and its response, we have been able to indicate several areas that are in need of improvement.

The simplest way to convey this information is by reporting on an accident one at a time. The following accidents took place within the last four years. We have summarized our observations, as well as the information provided by the personnel involved in the following pages. We obtained some of the information first hand through interviews with victims (Appendices L, M and N). We uncovered other details by interviewing bomberos and police that responded to the accident, as well as other informed experts of the case.

4.1 Individual Accident Analyses

The accident sites that we visited are further analyzed and discussed in the following sections.

4.1.1 Nosara, Nicoya, Guanacaste – February 29, 2004

Señor Emertio Araya, a farmer from the small town of Nosara in the province of Guanacaste, approached his usual products supplier for a chemical he could use to deparasite his cattle. He was referred to a product called Metafox™ (Remason 1211) by his usual supplier, and told to apply it directly onto all of his cows. Approximately one year later, Sr. Araya and his son prepared the compound and applied five gallons of it to the cattle. Within minutes of application, they noticed that the cows started knocking into each other violently, and then dropped to the ground. Sr. Araya's son began coughing violently soon after the cows showed these first symptoms. Realizing the presence of a problem, Sr. Araya dialed 911 at three pm. The closest emergency response unit, located in Nicoya, forty kilometers away, arrived at the scene approximately two and a half hours later. Also present at the site was the local Fuerza Pública[9]. The Cruz Roja immediately took Sr. Araya's son to Liberia Hospital due to his grave condition. He suffered from respiratory problems and loss of sphincter

[9] Police Force

control. He was placed on glucose drip and was hospitalized for eight days before released (Appendix L).

In order to ensure the safety of the public, forty people in a hundred-meter radius were evacuated for ten hours. An isolated zone was created such that nobody could enter the contaminated area. Representatives from the Ministerio de Salud as well as the MAG visited the site for evaluation purposes. The Ministerio de Salud advised Sr. Araya to burn and bury the twenty-one cows and two bulls. Sr. Araya accordingly burnt and buried the cattle in two separate pits that were four meters deep and twenty meters wide.

Upon visiting the site of the incident, we investigated the two pits where the cattle were buried, as well as the site where they were sprayed with the Metafox™. The burial sites showed no signs of contamination. Vegetation on and around the area seemed normal, and if any damage had been done, full recovery had taken place. In addition, we were informed that the cattle currently raised on the farm feed from the areas that were previously contaminated and there have been no additional problems. The family had also not experienced any adverse effects on their health.

Figure 5: Collection of soil samples

We took two soil samples from the affected area (see Figure 5), approximately ten square meters, in the barn where the cattle were sprayed with the chemical. The original canister, shown in Figure 6, contained the product was also taken to the laboratory for analysis. Unfortunately, we were never able to analyze these soil samples because of cost constraints. It costs eighty thousand Colones ($168) to analyze one sample, and a good site analysis involves at least three samples from the same area, according to Lic. Ana Lorena Arías of Surá. In addition, since this was within the enclosed area of the corral, there was no way of judging if any damage to vegetation or soil was present.

Figure 6: Canister containing Metafox™

After interviewing officials from the Ministerio de Salud, we found that the product used was actually a weed killer rather than a deparasiting chemical, and thus toxic in the quantities applied to the cattle. Metafox™ is a moderately toxic chemical that is absorbed through the skin and can cause severe respiratory problems. In cases of contact with high concentration or prolonged exposure, death may result. However, we also found that the chemical was an organophosphoric, meaning it would break down naturally over time in the soil and render itself inert. This is probably why the area had shown no signs of damage only a year later. Hence, we knew that our evaluation system should describe this accident as reversible, independent of human intervention

Officials from Ministerio de Salud as well as the Bomberos also suggested other possible reasons for this incident to have taken place. Since neither Sr. Araya or his son are literate, they were not able to read the canister containing the chemical. It is very likely that they did not follow the correct instructions on how to dilute the compound to a usable quantity. The resulting high dosage might have been the reason why the cattle died almost instantly after being applied with the Metafox™. This incident could also be attributed to the fact that they used the chemical a year after purchasing it. According to the Ministerio de Salud, it could have passed its expiration date and have turned into a more toxic compound than intended, leading to undesirable results (refer to Appendix L for interview with Ministerio de Salud).

In order to evaluate the environmental impact of this accident, we entered the details into our algorithm, which yielded an overall impact of 3.9 out of ten. This rating is in the lower percentile, leading us to believe that this accident only had a slight impact on the environment. This is consistent with the fact that no vegetation, soil, or water sources were affected. However, the death of domestic animals did add to the environmental impact.

We chose to not classify domestic animals with wildlife since they are contained in an enclosed area and in case of an accident they do not have the capability to run away to protect themselves, while wildlife will immediately flee at the first sign of danger. Moreover, the cattle in this case were part of the primary cause of the incident, and thus, their death cannot be recognized as an environmental impact.

The human impact of this accident was rather large for Sr. Araya. The total loss of cattle amounts to around eight million Colones (US$ 17,000) – which is a considerable amount of money not only to a farmer in rural Costa Rica, but anywhere in the world. In addition, the fact that his son had to be hospitalized for eight days adds to the severity of the situation.

At this site, we discovered that when only vague reports from authorities were available to us, we had to depend on information from interviews that was not always reliable. Sr. Araya, for instance, informed us that fifty-six cows were killed, when in actuality twenty cows and two bulls were killed. In addition, he insisted that the same thing had happened at another farm where more than forty cows were killed, but we could find no records of such incidents with either the police or fire department.

In this case, clearly labeling the product would not have helped, but there should be some system in place to be sure that farmers are using chemicals correctly and not contaminating their own farms and livestock. However, it appears that any investigation into this case was not extensive, and the cows and Sr. Araya's son paid the consequences.

4.1.2 Zeledón, San Rafael Norte, San Isidro - November 19, 2004

The international highway in the southern part of Costa Rica is an important artery to the economy of the country. Everyday, this highway is heavily traveled by hundreds of tanker trucks, transporting a wide variety of materials from the Atlantic coast into San José and other major cities. Sometimes the contents of these trucks are harmless food products, such as bananas or farm animals, but often they contain toxic chemicals that are dangerous to people and the environment.

There are many characteristics of this route that make it dangerous to travel. The highway twists through the mountains south of San José for many kilometers, and in most places, the roads are extremely steep and winding. A thick fog often obscures visibility because of the high altitude, which is nearly three thousand meters above sea level. Moreover, tankers are often not labeled or labeled incorrectly, creating an even more dangerous situation. This means that in case of a spill, it can take local authorities hours to identify a chemical. Despite all of these dangers, truck drivers will often speed down these roads in an effort to accomplish as much as they can in as little time as possible, in order to increase their earnings. For the same reason, they will also work extremely long hours, depriving themselves of sleep and thus inhibiting their driving abilities.

In November 2004, a tanker carrying both regular gasoline and diesel traveled along this highway in San Isidro. The driver had been speeding for quite some time, and as a result of the immense amount of friction on the brakes, they heated up to temperatures that degraded the material. As the tanker approached a turn in the road at the bottom of a hill, the brakes failed completely, sending the tanker off the road and causing it to overturn, as seen in Figure 7.

Figure 7: Overturned truck in San Isidro

Fortunately, no one was injured in this particular accident, however, all of the contents of the tanker leaked directly onto the side of the road. In order to prevent surface runoff, the local fire department deposited soil on the gasoline to absorb as much of the chemical as possible and prevent the spread of contaminants. The Bomberos also used dikes to contain the fuel (Appendix N).

Weeks later, a leaking tank of water two hundred meters further uphill from the accident washed the contaminants into a stream. This waterway is one of the many small tributaries running into a main river in the area that supplies the local people with potable water. There are two water-treatment plants in the area, one downstream and one upstream from the point at which this tributary joins the main river. At the plant downstream from the leak, workers noticed unusual substances in the water and closed off pipes supplying water to the community (Appendix N).

Upon visiting the site of the accident in June 2005, there are still visible effects of the pollution in the soil and stream. Upstream from the spill, the local flora is healthy and green, and the stream is relatively clear, with a layer of green moss covering the rocks. However, at the site of the spill, long reddish brown moss covered the rocks, indicating contamination. There are also several dead plants and trees near the stream, illustrating the effects that the chemical had on the soil. A few centimeters into the streambed, directly underneath the new red soil spread over the spill, is a thick layer of blackish-gray soil emitting a strong odor of gasoline. This condition is present along the stream from the area of the spill to a nearby drain, which directs the stream underneath the highway.

This incident represents a risk to the surrounding environment. The waterway transports the pollution further downstream and eventually to the ocean, depositing gasoline on the banks of the tributaries and main river. The stream will take a very long time for full recovery and may not be completely clean for decades to come. As gasoline sinks into the soil, the groundwater becomes more contaminated, a condition which is unavoidable and very difficult to remedy.

When we applied our model to this accident, it yielded a 5.1 out of ten level contamination. This number is higher than the first case for a few reasons. One important factor is the presence of a stream, which can carry contaminants as far away as the ocean, affecting wildlife along the way. While there appeared to be no affected animals, the vegetation clearly suffered and the soil remains very contaminated. The human impact in this case is high because the stream connects to a main river, which supplies the water treatment plant. In addition, the costs of response for the Bomberos were high in terms of equipment and materials used. Any cleanup would require an enormous amount of money, possibly in the hundreds of thousands of dollars.

We obtained more information than applies directly to the environmental aspect of this accident. A representative from the local water treatment plant explained that there is no contingency plan in place in case of a spill directly into the facility. Currently, the water is filtered only by allowing it to run through tanks, filtering out solids, and then treating it with chlorine before distribution to the public. In case of a spill, the responsible oil company is obligated to provide a carbon filtering system to the plant. Local people who depend on this water supply are informed by word of mouth following the plant's announcement that a spill has occurred. Apart from these measures, there is no way to clean the water or provide the local people with a different water source.

4.1.3 Highway Cajon de Pérez Zeledón, La Ese – August 21, 2004

On August 21, 2004, a truck carrying 21,500 liters of diesel fuel and nine thousand liters of gasoline drove off the highway in San Isidro, spilling its contents into a stream directly below. The cause of the accident was operator error. The driver, who had been driving for two days straight without resting, had fallen asleep at the wheel. The accident had an immediate and severe effect on the environment. Residents reported spotting hundreds of dead fish floating on the surface of the water and washing up on the banks. Plants in the area began to shrivel soon after the accident occurred because of the level of contamination to the soil (Appendix M).

The immediate area of damage was approximately fifty square meters, but because of the presence of a river, fuel flowed many kilometers downstream, causing much more damage to the environment. The fuel did not ignite, and all of the spill washed directly into the stream and soaked into its banks. The fire department could do little to contain the spill because most of the material had washed downstream prior to their arrival. They followed standard procedure to contain the spill with dikes and sand, but gasoline sank into the soil, where it remains today, inhibiting the growth of new plant life.

When we first arrived at the scene, there was a heavy smell of fuel in the air, and wreckage from the truck remained at the side of the road. As we proceeded down the slope from the road approaching the stream, we noticed that certain plants were affected more than others were. For instance, most of the underbrush seemed to have no long-lasting problems. Many of the larger trees, from the road down to the stream, were dead or had dead branches. From these observations, we could only imagine the severity of the chemical spill when the accident occurred almost a year ago. Despite the effects of the spill still visible on the environment, we were surprised to see that fish had returned to the stream.

About ten meters downstream remained a very strong smell of gasoline. Soil along the riverbank looked either black with gasoline or reddish, covered with algae, as can be seen in Figure 8. Even in places where the vegetation seemed healthy, a strong odor and visible contamination remained. We took water and soil samples from the area of the river closest to the spill, as well as ten meters downstream where contamination was carried and fifteen meters upstream from the spill in order to obtain a control sample. Our intention was to study the level of hydrocarbons still in the water a year after the spill had taken place, however, we were unable to analyze the samples because of the costs involved.

Figure 8: Gasoline contamination

This accident yielded a level of 8.1 in our analysis. While it was very similar to the August accident, which had occurred on the same highway, there were a few distinct differences. The base number in our analysis for this case was very high because of the huge amount of chemical spilled. In addition, there were hundreds of fish killed because of the water contamination in this incident. Entire trees were also killed at this accident scene as opposed to just a few of the branches that we had seen at the previous site. Finally, because of the greater size and velocity of this river, more contamination was carried downstream, with visible effects on the streambed. This accident had the highest severity of the sites we were able to visit.

4.1.4 Total Gas Station, San José, June 6, 2005

On June 6, 2005, the San José fire department began receiving calls from local citizens reporting headaches, and the strong smell of gasoline in the area of the Total gas station. Both the Ministerio de Salud and hazardous materials unit responded to the scene and found that an underground gasoline storage tank was leaking directly into nearby streams. The hazardous material unit evacuated the surrounding area and emptied the underground tanks, flushing them with water, in an attempt to prevent more chemicals from seeping into the ground.

We learned of the details surrounding the Total gasoline leak by speaking with Álvaro Sánchez Campos and two Tibás Bomberos in a small group interview. Although two weeks had passed since they responded to this accident, the Bomberos still had unanswered questions. For instance, they were sure that there was a gasoline leak, but could not determine if a tank or a pipe was leaking, or how far down the leak extended. Unfortunately, since they did not have control of the area, they had to wait to be able to examine the pipe system, a frustrating dilemma for the Bomberos. Meanwhile, gasoline continued to leak into the surrounding area (Appendix O).

When we asked the Bomberos what they could do to improve such a case, they expressed a desire for the public to be able to recognize such emergencies and call the fire department early. There is a lack of awareness surrounding hazardous substances that could be remedied if the people who lived in high-risk areas were educated about the danger. We were told that the resources and training was adequate to deal with this situation, if only they could have gotten there sooner to stop the leak.

Figure 9: Total gas station

Another source of frustration was that the Bomberos could not gain control of the scene. Because it was on Total property, they could not enter the scene of the accident after they first responded (see Figure 9). This meant that the Bomberos could not appropriately remedy the situation and stop further environmental damage. This puts the whole area at risk, making the residents vulnerable to sickness because of exposure.

In the absence of officials to interview, we talked to the people living nearby in hopes of gaining some more details. Three women spoke to us who lived with their family next door to the gas station and next to a stream where much of the contamination had leaked. They told us that someone had been taking samples, but that the stream was polluted prior to the accident. From what residents told us, the stream remained polluted for some time with visible trash and discoloration of the water. The oldest of the women complained that she had been living there all of her life and in the past few years it had deteriorated to this condition. Unfortunately, she did not have the resources to move away.

The Bomberos were under the impression that the Ministerio de Salud had been taking samples from the Total accident, so we traveled to the main office in San José in order to speak with a representative. In their investigation, they found that the gas station had been operating under an expired license for two years. This was because the tanks, including a drainage tank, which held the runoff gasoline and oil underneath the ground, could not pass required inspections. We learned that previously the station had operated with an expired license for a year as a Shell station. Unfortunately, the Ministerio de Salud does not have enough time to check on all of the gas stations to be sure that they have licenses, and the problem went unnoticed until an accident occurred. The Ministerio de Salud was unable to conclude whether the leak originated from a drainage tank, gas tank, pipe, or any combination of possibilities. In this particular incident, the Ministerio de Salud had jurisdiction over the site because they were in the process of investigating this matter (See Appendix O). Consequently, the Bomberos could not gain access to the site, as they normally would at other accident sites.

In the United States, environmental experts would have had greater authority in a similar case. Under the RCRA[10] amendment, courts can expediently open private property to experts studying the damage done to the environment. Quicker action means that chemicals have less opportunity to damage the environment and spread to surrounding areas.

From further investigation at the Ministerio de Salud, we learned that they never took samples, but believed that MINAE had. The Ministerio de Salud representative reluctantly informed us that different agencies do not collaborate on what information is collected or by whom. Perhaps most importantly, agencies collect this information but rarely do they combine it into a full report. There is no protocol for collaborative data collection, but there is certainly a need for one. Once again, we found ourselves being told by a government representative that she wished for more communication between ministries.

This accident was rated as a six out of ten. Approximately 53,000 liters of gasoline leaked into the soil and the stream. The fact that the tanks had not been removed makes the leak a continuous problem. Since the pollution had been so bad as to give people headaches, we factored this into our human impact number.

[10] The Resource Conservation and Recovery Act

4.2 Model Evaluation and Improvement

Once hearing our project description, both Professor Eduardo Rivera of the University of Costa Rica (UCR), and Lic. Ana Lorena Arías of Surá said that given the time and resources we had, the project as it was defined, was not achievable, for it would be like converting rocket science into a coloring book. According to them, we needed not only more expertise in the field of environmental risk management engineering, but we would also need more manpower if we were to collect samples and visit all ten of the past accident sites. Our knowledge as students was very limited in this field, and thorough analysis of samples was beyond our capacity. For a comprehensive environmental impact assessment to be executed, we would have to take into account all the variables involved with the accident. This would include considering chemical properties such as dilution levels in bodies of water, or their residence time in soil (See Appendix G). Determining such information would take up a considerable amount of time. Conversely, omitting this level of detail would not be detrimental to the creation of our final product. Therefore, even though we wanted to include as much detail as we could in our final model to increase the validity and accuracy, it was beyond the scope of this project as well as our knowledge. This meant that the newly defined product would be more basic than originally intended.

Turning to expert sources for help, we found that for the most part they had difficulty offering us constructive feedback, due to the extensive nature and depth of our goal. Lic. Ana Lorena Arías was one of the few experts that offered us resources to improve our model. In addition to experts, we also turned to research material for reference. From our research, we found that even though impact evaluations had been done individually on soil, water, air, flora, or fauna, there were no models that considered all the aspects. These individual models were far too detailed for us to implement and still conserve the Bomberos' goal of creating an easy-to-use model. As a result, we formulated the whole model ourselves, which is why we presented it to as many experts as possible with the intent of gaining their approval and implementing their recommendations.

The first person to look over our work was Ing. Álvaro Coto Rojas, an environmental engineer from RECOPE. He advised us to redefine the classification of animals that we chose to use. There is a distinction, for instance, between rare animals, protected species, and endangered species. It is a very different matter for ten endangered wild cats to perish as opposed to ten dogs. As a result, we have added different categories of animals to our model and given them different levels of importance. He also reemphasized the importance of distinguishing between domestic and wild life, as previously discussed in Chapter III (See Appendix J).

Apart from this, we were advised to reassign values to some of the chemicals involved in our analysis. While the EPA categorizes all petroleum products together, diesel fuel, according to Ing. Álvaro Coto Rojas and Lic. Ana Lorena Arías, is much worse in water than regular gasoline (Appendix R and Appendices H and J). Diesel fuel has a low vapor pressure, meaning it has a low tendency to evaporate into air. Bunker, another petroleum product containing MTBE[11], is still worse for the environment and is considered among the worst environmentally threatening chemicals. MTBE is an additive in gasoline that helps cars burn fuels cleaner. MTBE is highly miscible in water, and has been found in many water sources in the United States. Certain states including California banned the use of MTBE in 2002. As a result, we assigned bunker a high level of 0.8, as opposed to its previous value of 0.6.

There are many knowledgeable environmental engineers at Surá. We had the opportunity to speak with Lic. Ana Lorena Arías once again, as well as a coworker of hers who is also an authority in environmental assessments. Several other factors, which required attention, became clear to us and because of these meetings; the model was revised once again.

Lic. Ana Lorena Arías's colleague was satisfied with the structure of our system but thought that it was incomplete as far as the details that we chose to consider. The first thing that he noticed was that we needed more detail about the weather at the time of our accident. The speed of the wind is not complete enough to describe where the chemicals will spread (Refer to Appendix I).

Furthermore, the types of surfaces that the spill takes place on will also determine how quickly the chemicals are washed away or soaked into the ground. We have added a category for type of surface into our system because of these findings; differentiating between concrete, hard ground, and soft soil. Other factors also contribute to how fast the chemical is carried to other areas by

[11] Methyl Tert-Butyl Ethyl

waterways. The inclination of a river is important, for instance, since a steep river will carry chemicals downhill rapidly. If a spill occurs next to the ocean, the currents and tides needed consideration in the model. We had not included the possibility of water changing direction before this, and had only considered rivers. The dilution of the chemical in the river is also very important. While this is something that we felt was important to consider in our model, we could not take it into account because of the need for a tool that requires easy-to-collect information.

One very important point that was brought up was that our model should come with a full explanation. This requires us to write a manual for proper usage of TEEICI by the Bomberos. This manual should include a time limit for valid use of the model. The tool is made for use by the Bomberos right after a chemical accident has occurred and is not valid after twenty-four hours after the accident. The Bomberos should be fully aware of this, as well as any other conditions for use of the system. However, the explanation should be short enough that any of the Bomberos can read quickly at the scene of an accident and immediately be able to run it. A copy of this manual is attached in Appendix D.

Lic. Ana Lorena Arías's comments echoed those of her colleague as well as those of Ing. Álvaro Coto Rojas' from RECOPE. She also asked that we re-categorize some of the chemicals that the EPA scale did not mention in enough detail. For instance, organic waste is very dangerous in large amounts and should be categorized with gasoline and other petroleum products. We were also urged to consider the reversibility of accidents in the definitions of each level of contamination. With the primary purpose of the tool being for use in court, it is imperative that it be sound enough to endure cross-examination; therefore, we need the approval and input of as many experts as possible to improve and calibrate the model (Appendices J and H).

TEEICI has great potential, but will be limited without the data stored accessible for anyone who wishes to use it. This means that a database will require accessibility to many private and government agencies and have the ability to store vast quantities of separate incident reports. Our research unfortunately has shown that creation of a database with easy file sharing will be very difficult. This is because firstly, not all government offices have access to computers, and secondly, there is no file system that all offices can easily access. In addition, most government offices have more work to attend to than they can handle, and adding further responsibilities would not be plausible in terms of time, personnel, or finances.

In order to obtain the details surrounding each accident that we studied, we traveled to many different companies and agencies to conduct interviews. This can take days, since important information is often scattered among different organizations and pertinent witnesses are sometimes unavailable. The information recorded by authorities following an accident is often incomplete, requiring interviewees to fill in gaps of information, which may be biased. A full accident report and conclusion is never coordinated between separate ministries, making the process of piecing together an incident much more difficult.

The leak at Total is typical of the accidents that we have studied. Many different experts from the Ministerio de Salud, RECOPE, A y A[12], as well as the Bomberos have told us that there is very little communication between organizations researching and reporting hazardous accidents. Police records are vague, and the ministries involved often do not collect all the required information. Such gaps of information lead to the lack of enforcement of certain issues, and those at fault are subsequently not held responsible. In the Total case, even though the operation license had expired, the station was in service, unnoticed by the proper authorities.

The result is that accidents such as the Total gas station are rarely pursued, and so the owners hardly ever have to take responsibility for their lack of care. The local environment, as well as the people who are forced to live in areas of the city contaminated by toxic chemicals, has to pay the price for the polluter's negligence. One family that has been living near this particular gas station for many years pleaded with us to remedy the situation, since they do not have the resources to move away.

Another disturbing trend that we have come across while collecting the details of each accident is that in almost every case the cleanup performed is inadequate. In most cases, nothing is done to remedy a spill, and the chemicals are left to leach into the ground or seep into nearby waterways. This happens for a number of reasons. Sometimes the identity of the chemical is unknown, or there is no available method for cleanup. Spills are absorbed with foam and

[12] Instituto Costarricense de Acueductos y Alcantarillados (Water Treatment Agency)

sand or contained with dikes, but the contaminated soil is rarely cleaned or removed.

Often, there is a lack of cleanup due to confusion of who is responsible, another aspect of the prevalent communication problem. In San Isidro, the company at fault for an oil spill was asked to remove the contaminated soil but refused because of the enormous expense. No conclusion was reached because authorities did not further press the issue. The gasoline sank deeper into the soil, killing plants and animals and leaking into a nearby water supply.

Even when companies do take responsibility, there is little that they can do. The environmental engineer at RECOPE explained in his interview that it is illegal to use bacteria to clean-up oil spills outside of the RECOPE facility because of a lack of information. Before they can begin to use this method, there must first be a study of the environmental impact of the bacteria to see if they impact flora or fauna.

One alarming trend that we uncovered throughout our research was that many times there is preventative information available that is ignored by the authorities. One case of this was concerning the locations of underground gas lines. Gasoline leaks are often caused by highway repair crews that accidentally puncture underground gas lines. At first we were told by the Bomberos that the road crews do not know where the lines are because they are not marked, however, according to RECOPE, this is not true. Upon visiting RECOPE, we learned that they indeed do map all of their pipelines and distribute these maps to all of the local authorities. Last year they held nine meetings with Cruz Roja, the Bomberos, municipalities, National Commission of Emergencies, and local emergency commissions encouraging the use of this information. When we asked them to explain why these maps are not used, the Bomberos as well as Ing. Álvaro Coto Rojas could not explain.

We have also found that areas of high risk to chemical accidents have no warning systems in place to alert people of dangers such as toxic drinking water. The Bomberos already use GIS to map fire hydrants and locations of dangerous incidents, and we find that it would be beneficial for them to use these systems to map out areas of high risk. The Bomberos could give these areas special attention and contingency plans in case of an accident. For instance, gasoline stations and refineries could be mapped out and monitored. In the case of the Total gasoline station leak, when asked what they wish could have been done better, the Bomberos hazardous materials team stated that they wish the local people had called them sooner. If this area were previously identified as high risk, information could be distributed to the neighboring families instructing them on the signs of a chemical leak and what actions to take.

Many accidents in Costa Rica were caused or worsened by the absence of proper labeling. Improper labels on trucks shipping dangerous materials often prevents local authorities from learning what is being spilled after an accident occurs. To make matters worse, trucks shipping non-hazardous materials are commonly labeled with hazardous materials stickers as a matter of style (see Appendix K). This is very dangerous to the people in the area of an accident as it can take hours for the Bomberos to find out what they are dealing with. By this time, it may be too late to do anything in the way of cleanup, or warn the local people to stay away from the area.

In other cases, tanks and valves can be mislabeled, preventing first responders from using emergency shutdown systems properly. In one case, during a chlorine leak, the Bomberos unknowingly worsened a situation because of a lack of instruction labels on the tank. The Bomberos were accustomed to a particular type of valve commonly used at similar facilities that works in the opposite manner. When they approached the tank, their experience told them that the valve on the tank was open and needed to be closed, when in actuality, the valve was already shut. Thinking that they were closing off the flow of chlorine gas, they opened the valve, allowing more to escape and worsening the situation. It is unfortunate that a simple label could have prevented this development. It should be clearly indicated on tanks how to operate safety valves and emergency shutdown systems so that the Bomberos do not have to make guesses in a dire situation (Appendix Q).

The lack of contingency planning for many different scenarios in areas around the country is distressing. In many areas, there are absolutely no evacuation plans. In fact, there are hardly any systems to alert the public of emergencies apart from word of mouth. There are areas with water treatment facilities that have no plan for chemicals that spill into the water supply. In addition, because areas of high risk remain unidentified, local authorities are sometimes not ready to deal with them. In contribution, there are many areas without a fire station, slowing response time to several hours.

Evacuation and public alert systems should be in place everywhere in the country, but in the absence of such measures, it is important that these plans be in areas of high risk, such as storage facilities and well-traveled shipping routes. The water treatment agency, A y A, informed us that the public alert system in Costa Rica is based on word of mouth. When an accident occurs, the local government heads are informed of the situation, after which it is their responsibility to ensure that citizens in their area understand what has happened. While this may work in small communities, it is not a reliable way to spread information and can certainly be improved.

In May 2005, an event in La Fortuna, a mountain town in the center of the country, illustrated the need for more fire stations and better access to remote areas. A supermarket burned to the ground without attention from the Bomberos. The nearest station is hours away from La Fortuna, a town located at the base of Volcán Arenál. This lack of safety is present in many areas of the country.

The Bombers are in need of many more facilities. Unfortunately, they do not have the resources to build fire stations in all of the areas that need them. However, in the absence of a fire station, there should be some local authority with the knowledge to respond to an emergency such as a fire or a chemical spill. The local people cannot be left to their own devices in the case of such an emergency.

The lack of resources in this country has prevented the adequate upkeep of all of the road systems, but this is still a matter of safety that authorities must address. We have found that in Costa Rica some of the roads have severe damage and are in need of immediate attention as seen in Figure 10. Poor road conditions delay emergency crews from reaching accident scenes in a timely fashion and can also be the cause of accidents. Some possible factors that would be appropriate for analysis include the tendency for mudslides to occur and the severity of potholes in the road.

Figure 10: Dangerous road conditions

Despite having had interviews with representatives of many branches of government including the police, the Bomberos, Ministerio de Salud, and several others, we were unable to obtain statistics on traffic accidents or transportation accidents involving chemicals. We were also unsuccessful obtaining information regarding the level of law enforcement in Costa Rica, such as number of traffic tickets given out for speeding and violations regarding hazardous materials. Without this basic information, we cannot be certain whether police are doing all that can be done to prevent chemical accidents.

When asked what contact the Bomberos office of engineering has with the USEPA, we were told that they have none at all; however, they are very interested in such contacts. This has become clear to us in our work because the authorities in the engineering office have asked us to base some of our assessment on systems that are already used by the USEPA. We believe that while environmental attention here should be based on local attitudes and values, there are many potential advantages to setting up relations with INS and the USEPA. For instance, there are many research studies available to the USEPA that would also be useful to the Bomberos. It would be beneficial to share this information internationally.

Chapter V: CONCLUSIONS AND RECCOMENDATIONS

Costa Rica faces extensive problems posed by the chemical industry. A large issue is that a proper system is not in place to facilitate communication between government branches. This creates a climate where the passing of legislation and law enforcement are extremely difficult. As a result, chemical accidents are frequent, often not cleaned up, and those that are responsible for chemical incidents are not held accountable.

The Bomberos require the development of an environmental assessment tool that serves two purposes:

1. Assesses the overall impact a chemical incident had on the environment to be used at the Environmental Tribunal, the purpose of which would be to hold people responsible for the level of damage they cause to the environment,
2. Determines whether nature is capable of recovering without the need for human intervention.

By utilizing TEEICI, which can perform the aforementioned functions, the Bomberos have a tool that will assist them in making the environment a cleaner place.

Before the Bomberos can begin use of TEEICI, we have some concerns. The tool requires further testing on more accidents in order to determine the level of accuracy evaluating the damages. In addition, TEEICI would best serve the nation of Costa Rica if the information obtained from the tool were shared with concerned branches in the government. If the judicial system in Costa Rica starts accepting TEEICI as valid evidence, it will have a profound effect and hold people accountable for their destructive actions against the environment.

In Costa Rica, standard means of determining the environmental damage of chemical incidents are not appropriate. Funding to determine the level of damage done to the environment by chemicals is extremely limited in Costa Rica. Most environmental studies cost thousands of dollars and require many weeks for a team of well-trained experts to determine the full extent of damage. In Costa Rica, governmental organizations sometimes have problems gaining access to sites, especially when they occur on private property. TEEICI assists the Bomberos work around these dilemmas.

TEEICI requires no costly lab results, and information needed for the device can be collected in a matter of hours; not weeks. The financial cost of making a fast and accurate environmental evaluation with this device is virtually none. Because data for TEEICI does not take very long to collect, a full environmental study can be made directly following the stabilization of a chemical accident scene. This will allow the Bomberos to make a complete environmental assessment of a scene, even if it occurs on private property. TEEICI, with further testing and calibration, has the potential to be a widely used tool by the Bomberos. It will make presenting data to courts easier, which in effect will hold those at fault accountable for these accidents.

The nature of our research lead us to many different offices around the country to gather accident information. Throughout this process, we encountered ways that public and private agencies might improve their levels of efficiency. The information gathering process for any researcher in Costa Rica is tedious because of infrequent communication between different branches of government. Given the quantity of obstacles we came across while conducting our research, we compiled a list of recommendations that should make the process easier in the future. Many of these recommendations have the potential to be explored by WPI students conducting IQPs.

1. Creation of a Central Database

We propose a central database containing details of each accident. This database would be available in hard copy or online, with the responsibility of maintaining and updating the system under a single organization. The responsible organization would need to have the funds to keep the system well updated, which would be optimal for the Bomberos who have the necessary resources.

2. Appoint Emergency Response Personnel in Rural Areas

Remote areas need to be assigned a point person who is given some training and a plan to deal with emergencies. This person could be a volunteer, a police officer, or even a local citizen.

3. Remedy Areas Needing Road Repairs

Improving road conditions in rural areas would allow easier access for emergency personnel. This project would involve uncovering areas of high needs and recommending where to best direct funds for road repairs, obtain sources of revenue, and suggest changes for the movement of hazardous materials to safer routes.

4. Educate Students about Environmental Danger

A project could investigate changes to the curriculum to make people more aware of these issues or explore the possibility of raising public awareness.

5. Increase the Authority of the Bomberos

The Bomberos need more authority to investigate accident sites after they have been stabilized. Legislation needs to be passed so that the Bomberos and other government organizations may begin cleanup more quickly, and identify causes of chemical accidents to hold those at fault accountable.

6. Establish Relations between the Bomberos and USEPA

The Bomberos are interested in the environmental regulations that exist in the United States. Case studies could also be shared in this relationship to further the understanding of the effect chemicals have on the environment.

7. Create Contingency Plans in Areas of High Risk

Communities near facilities housing vast quantities of hazardous materials require contingency planning in the case of an accident. Areas of high risk need identification and proper plans for adequate response.

8. Increase Accurate Signage on Vehicles

It would be very beneficial to impose harsher penalties on drivers that mislabel their trucks. A project could also be done to improve the course truck drivers must take before obtaining their licenses.

9. Study the Use of Bacteria for Consumption of Hydrocarbons in Oil Spills

Before bacteria can be used to clean up spills of petroleum products, a study must be conducted on the environmental effects of the bacteria.

10. Global Applications of TEEICI

There are many countries in Central America that would benefit from an environmental assessment system, especially less developed nations that may not have the resources to carry out extensive investigations. Costa Rica could lead these countries in utilizing TEEICI and other environmental programs.

The Bomberos alone cannot carry out the suggestions stated in this section. It is crucial to develop better lines of communication between separate branches of government for these recommendations to be followed through. Future projects with WPI would definitely help fix the problems we encountered in our project, as well as raise more concern and appreciation for the environment.

APPENDIX A – El Cuerpo de Bomberos

A governmental umbrella organization, the INS (Instituto Nacional de Seguros), was founded in 1924 with the aim to respond to and deal with the protection needs of Costa Rican society. Over time, INS has evolved to offer a wide range of protection services to its people, from financial security to safety from chemical accidents. INS currently incorporates eleven agencies that provide healthcare, banking services, and an organization similar to OSHA (Occupational Safety Hazard Administration), which deals with occupational risks to the Costa Rican public.

El Benemérito Cuerpo de Bomberos, or the firefighting department, is now a part of the parent group INS but was founded much earlier in 1865. Costa Rica lay exposed and vulnerable to dangers such as fires. In January 1864, one of the grandest houses in San José caught fire and was destroyed. At this point in time, an adequate fire protection system was not in place, and thus caused uproar amongst the Costa Ricans. This is when the Governor of San José proposed that a fire truck be imported from the United States. The truck arrived a year later in June 1865, and in July that year, the Cuerpo de Bomberos was officially formed.

During the early 1900s, arson grew in Costa Rica mainly due to fraudulent insurance claims and other such activities. To combat this, several laws were passed that would prevent claiming false insurance compensations, and in addition, ten percent of the premiums paid by fire insurance was to be devoted towards acquiring new firefighting equipment (http://www.ins-cr.com/esp/Historia).

El Cuerpo de Bomberos has progressed through the use of technological advancements and the improvement of response rates, made possible by numerous external grants and studies. It continues to strive to improve the infrastructure by adding more technology that will better help assist the Costa Rican population of four million.

A simple organization structure defines the Cuerpo de Bomberos. The Director, Héctor Monge Montero is the head of the entire Cuerpo, followed by Ana María Ortega, who is the information manager. There are then two main subdivisions: technical and administrative, as shown in the Figure 11 below. During this project, we will be working with Ing. Esteban Rámos González from the Ingeniería de Bomberos (Technical Subdivision), who is in charge of investigations and risk management, as well as fire prevention and education. La Dirección de Bomberos (the Administrative Subdivision) is headed by Chief Héctor Chaves, who is responsible for overseeing the general operation of all sixty-one fire stations in Costa Rica. This subdivision is then further divided into an Administrative and General Services section.

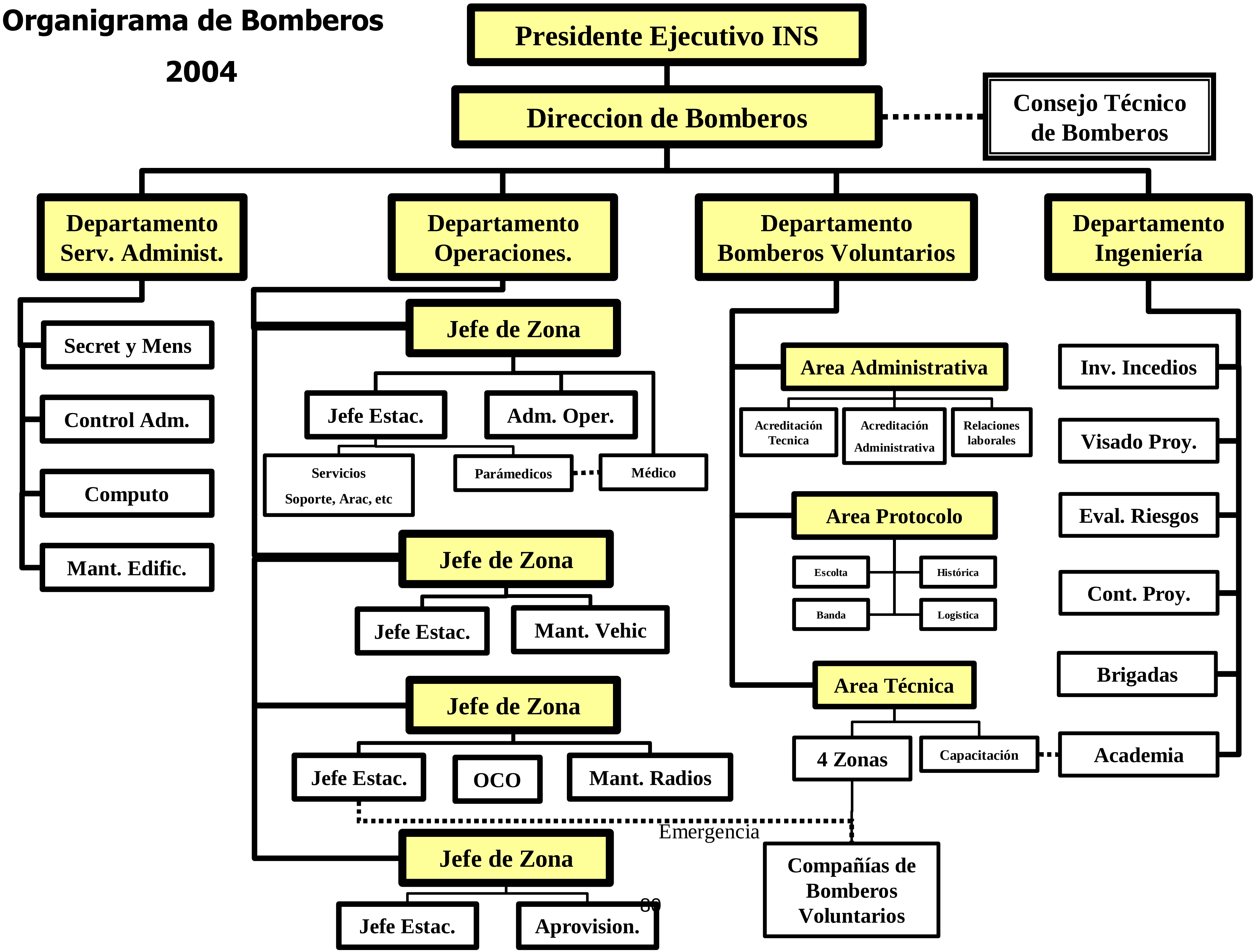
Since 2001, the budget for the Bomberos that is provided by INS has been increasing eight percent annually since 2001. They have an annual budget of $26.5 million and the rise comes directly from increasing insurance premiums and taxation of teachers' salaries. The allocation of these resources is controlled by La Dirección de Bomberos. This office also oversees policy management for the entire department.

There are a total of 540 fulltime firefighters and one thousand volunteer firefighters dispersed throughout the sixty-five fire stations located in the country. Each fire station is assigned a specific zone that becomes their prime responsibility in the event of an emergency, although other stations often assist neighboring units. Each fire station has two to three fire trucks, and at least one paramedics unit. On average, there are twelve firefighters and two paramedics on duty at any given time. La Oficina de Comunicaciones (OCO) is located in Santo Domingo and receives all national fire-related 911 calls. Three technicians coordinate these calls and dispatch the appropriate units nationwide. The dispatchers are also responsible for coordinating responses in the event of an accident, collecting information, and making detailed reports about each incident. In addition, three fire stations around the country are specially equipped to deal with chemical incidents. The primary station is located in Tibás, and there are two other smaller stations in Puntarenas and in Siquires.

The Bomberos are concerned about the environmental impact caused by the large number of chemical accidents. After an accident has occurred, several other governmental organizations ask the Bomberos for an evaluation of the environmental impact. To their dismay, they have never been able to adequately report on this aspect. It is our task to help them fill in these gaps of information by setting up an evaluation process that they can use onsite immediately after an accident.

Organigrama de Bomberos

2004



APPENDIX B – On-Site Data Collection Form

Reporte para Emergencias de Materiales Peligrosos **GPS**___________

Dirección de viento_____ velocidad de viento (kph)_____ temperatura de aire_________

I. Ubicación:______________ Fecha:______________

Tipo de Accidente:______________ Sustancias involucradas:______________

Clase de química:______________ ______________

Tipo de almacenamiento: ☐ Tanque ☐ Cisterna

☐ Estañones ☐ Envases ☐ Paquetes Volumen_______

II. *Si fue cisterna/vehiculo*

Empresa: ______________ Conductor: ______________

Placa:______________ Revisión técnica al día:______________

Señalizado:______________ Portaba fichas de seguridad:______________

Protocolo por matpel:______________________________

III. *Si fue tanque* -

Ficha de seguridad ☐ Sí ☐ No

Posición de la Válvula ☐ Abierta ☐ Cerrada

Capacidad ___________

Dique de retención ☐ Sí ☐ No

Señalizado ☐ Sí ☐ No

IV. *Control*

Contención:______________ Transvasado:______________

Dilución:______________ Encapsulamiento:______________

Personal involucrado:______________ Equipo Involucrado:______________

V. *Impacto Ambiental*

Personas afectadas

Civiles

Mujeres: Nº_______ Edades: ______ Hombres: Nº_______ Edades:________

Niñas: Nº_______ Edades: ______ Niños: Nº_______ Edades:________

Personal

Bomberos:Nº_______ Edades: ______ Médicos: Nº_______ Edades:________

Policía: Nº_______ Edades: ______ Unid Matpel: Nº_______ Edades: _______

Otros: Nº_______ Edades: ______

Animales Afectados: ______________ Hay contaminación: ______________

Contaminación del Aire: ______________ (volumen en m^3):_______ ☐ mal olor

Contaminación del suelo: ______________ (área en m^2):__________ ☐ color suelo

Contaminación del agua: ______________ ☐ Quebrada ☐ Pozos ☐ Laguna

☐ Río Distancia río abajo (en m): ________ ☐ Mar Área afectado (en m^2): ____________

☐ Otros Descripción: ______________________________

Daños a la vegetación: ______________________________

____

____

____

VI. Muestras: (condiciones, climatológicas, y hora recolección)

1.

2.

3.

4.

5.

APPENDIX C – Model with Weighted Values

Model to determine the environmental impact of chemical incidents

(Divide final number by 10 to yield environmental impact quantification)

<u>Base Functions</u>

Type of Chemical

X → **8**		*liters of chemical*
A → **7**	x	**10**: 1,500+
		9: 1,301 – 1,500
		8: 1,101 – 1,300
		7: 901 – 1,100
		6: 701 – 900
		5: 501 – 700
		4: 301 – 500
		3: 100 – 300
		2: < 100

Bunker → **8**
Gasoline Products → **6**
Organic Waste → **6**

B → **5**		
C → **3**	x	*liters of chemical*
D →**1**		**10**: >35,000
		9: 27,501 – 35,000
		8: 20,001 – 27,500
		7: 15,001 – 20,000
		6: 10,001 – 15,000
		5: 7,501 – 10,000
		4: 5,001 – 7,500
		3: 2,001 – 5,000
		2: 500 – 2,000
		1: < 500

Additional Functions

- If the chemical is more dense than water + 1

Type of Surface

- Pavement + 2
- Wet soil + 4
- Sandy/Loose soil + 5

In case of Gas

- If gas cloud is heading towards natural reserve + 4
- Wind speed
    - No wind + 2
    - Breezy (~5 kph) + 3
    - Windy (>10 kph) + 4
- In case of rain
    - Drizzle + 1
    - Normal + 3
    - Strong + 5

Water

- If river or stream present + 5
- If stagnant water present + 3

- Water speed
    - More than 16 kph + 0.5
    - Less than 16 kph + 1.5
    - Slow + 2

- Sea
    - If visible contamination in sand or water + 2
    - If accident occurs close to habitat of protected species + 5
    - Death of marine life + 4

Flora

- Natural reserve + 6
- Secondary forest + 4
- If plants burn or die instantly + 3
- Area of soil affected:
  - >2000 m^2 + 9
  - 1,501-2,000 m^2 + 8
  - 500 – 1500 m^2 + 5
  - < 500 m^2 + 3

Fauna

- Protected species + 9

- Death of fish + 6

- If animals die in a non-enclosed area + 9
- If a large number of animals (>20) die in a non-enclosed area + 10

- If animals die in an enclosed area + 7
- If a large number of animals (>20) die in an enclosed area + 9

APPENDIX D – Instructions Manual (in Spanish)

Guía para utilizar el modelo

Introducción

Ésta guía es intencionada para el empleo del *Modelo para determinar el impacto ambiental de accidentes químicos*. Ésta es una herramienta básica y sencilla que se puede usar para evaluar el daño hecho al medio ambiente después de un accidente.

El modelo es estructurado básicamente como un formulario. Al llenar todos los campos pertinentes, el programa calcula y lo muestra automáticamente el impacto ambiental. El modelo está basado en un programa que se llama MicrosoftOffice™ InfoPath™ 2003, y es ideal para llenar unos formularios y almacenar en una base de datos.

Favor recuerda que eso es una herramienta sencilla y por lo tanto no es absolutamente preciso. Sin embargo, lo hemos desarrollado a un nivel en que puede confiarse en los resultados. El número de impacto ambiental que recibe es una culminación de varias variables encontradas en la escena del accidente; entonces, es esencial que el asesor ingrese los detalles el mismo día o no serán válidos los resultados.

La escala

El número de impacto ambiental es entre 0 y 10, donde 0 significa ningún impacto, y 10 el impacto extremo. Los siguientes son descripciones generales de los impactos para darle al asesor un sentido de la escala y no son pautas fijas.

0 Ningún daño ha ocurrido. El área está en la misma condición en que sería si no hubiera un accidente.

1 Hay algún daño, pero al nivel más mínimo posible. El área afectada repondrá rápidamente. No hay ninguna muerte.

2 Ocurrió daño en una cantidad pequeña, que se arreglará dentro de un año sin intervención humana. Si hay muertes, fueron por el incidente en si mismo y no por la contaminación.

3 El pequeño daño se remediará en unos años sin intervención humana. Hay algún daño a la vegetación.

4 Hay daño visible a la vegetación y quizás a unos pocos animales o peces.

5 Ocurrió una cantidad moderada el daño. Algunos animales o alguna vegetación están destruidos, pero es probable que recuperarán sin intervención humana en una decena de años. Si hay algunas muertes por contaminación, son pocas. Es posible que la contaminación que queda se haga el área insegura para más exposición.

6 Un área grande se ha dañado. El suelo es bastante contaminado y es posible que no recuperará pronto. Por consiguiente, la flora y la fauna son afectadas también.

7 Mucho daño ha ocurrido. Unos animales mueren y la vegetación está sufriendo. Es posible que se contaminó una masa de agua. El suelo también está contaminado e impidiere el crecimiento de la vegetación.

8 Ocurrió daño severo. Un área grande de vegetación está contaminada. La fauna está afectada y posiblemente hay una gran cantidad de sus muertes. La recuperación está posible solamente con intervención humana, pero tardará varios años. Ésta área será peligroso para los humanos y otros seres vivos.

9 Una gran cantidad de daño extremo ocurrió. Una gran área del ambiente está destruida. Si el área puede recuperar, necesitare muchos años y un esfuerzo extenso para la limpieza. El área está altamente tóxica y es peligrosa en caso de exposición.

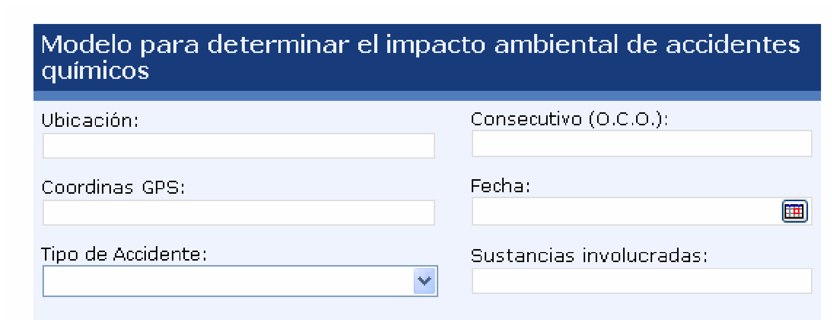
10 Son los peores accidentes que han ocurrido a lo largo de la historia documentada. Se usa éste nivel si un área muy grande fue completamente devastada, e involucran muertes de ambos animales y humanos. Un accidente de tal categoría está irreversible. Ésta categoría puede también ser usada en caso de la exterminación de una especie particular.

Recomendamos que si un accidente califique más de 6, que haga estudios más detallados sobre el accidente el asesor. Creemos también que para un accidente que reciba más de 5, sería difícil y prolongada recuperarse la naturaleza sin intervención humana de la limpieza.

El uso del programa

Hemos creado el programa así que sea tan intuitivo a utilizar para el asesor.

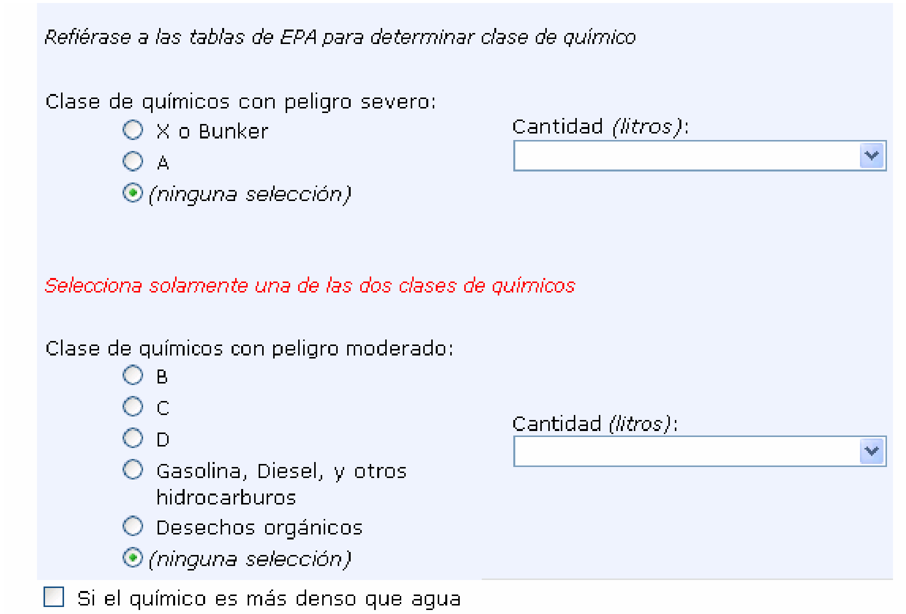
I. Datos generales



Éstos primeros seis campos son información general acerca del accidente y no afectan el número de impacto ambiental.

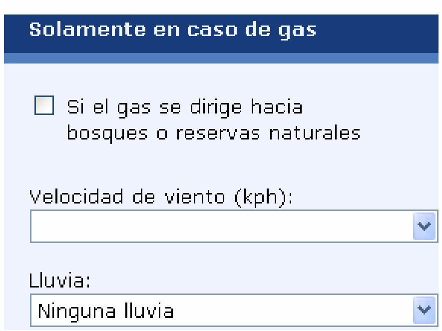
II. Información sobre el químico

Ésta sección está dividida en dos partes, y debe llenar solamente una sección. Para determinar cual tipo de químico es, debe referirse a las tablas adjuntadas de EPA, en que se clasifica cada químico par X, A, B, C, o D.



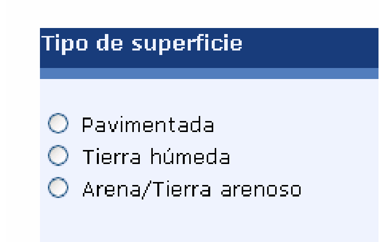
Si el químico de que trata sea Bunker, X, o A, elija unos en la parte arriba y escoja un rango describiendo la cantidad. Si no se trate de éstas sustancias, siga las mismas etapas en la sección abajo. Note bien que debe seleccionar solamente una de las dos secciones para que el programa funcione correctamente.

Llena la casilla si la sustancia es más densa que agua. Esto aumenta el riesgo que lleva un químico al medio-ambiente.

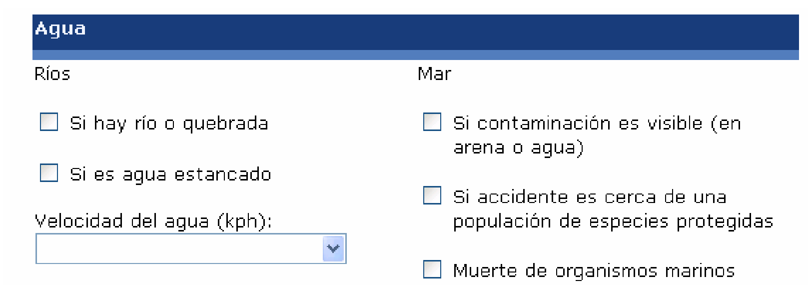


Si se trata de un gas, debe llenar ésta sección también. Los estados del tiempo son importantes en caso de fugo de gas porque puedan determinar como va a reaccionar el gas.

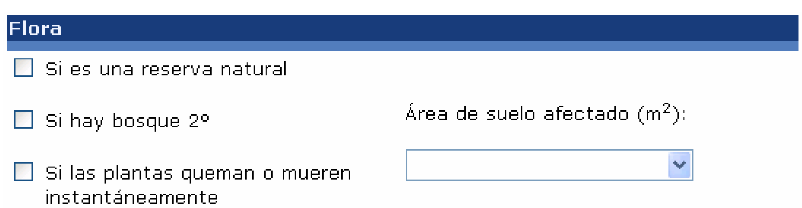
III. Detalles locales



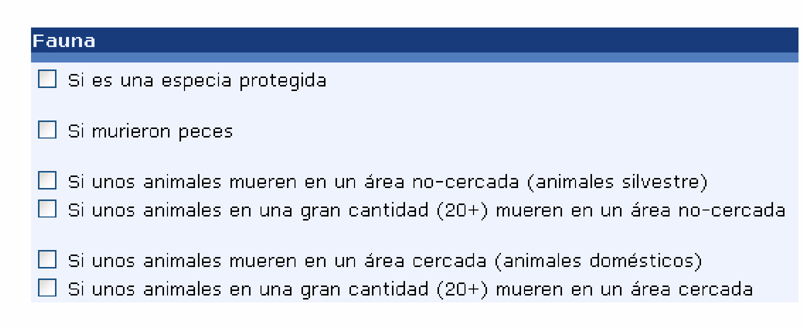
Debe seleccionar el tipo de superficie en que la sustancia se derramó. Si no aparece el tipo de superficie exacto, elija lo que está el más parecido. En la mayoría de los casos, sería tierra húmeda; pero por ejemplo, si hay un derrame en una carretera, aunque el químico está en una superficie pavimentada, va a llegar a la tierra, donde los efectos serían más marcados, entonces es mejor elegir tierra en tales casos.



Es posible que el químico entre en una masa de agua – agua estancada, una quebrada, un río, o el mar. Es importante seleccionar la velocidad porque afecta mucho el impacto ambiental.



Seleccione el tipo de área que se afectó. Es importante determinar si fue una reserva natural o la clasificación del bosque. Si la vegetación en ésta área murió instantáneamente al llegar en contacto con el químico, elija la última casilla. Hay varios rangos del área afectada que puede seleccionar también.



Si había animales que fueron afectados, debe llenar ésta sección. Elija la primera casilla si fueron afectados animales de una especie protegida.

Hemos diferenciados entre animales silvestres que viven en un área no-cercada y animales domésticos que viven en un área cercada. Dependiendo del caso apropiado, seleccione las casillas.

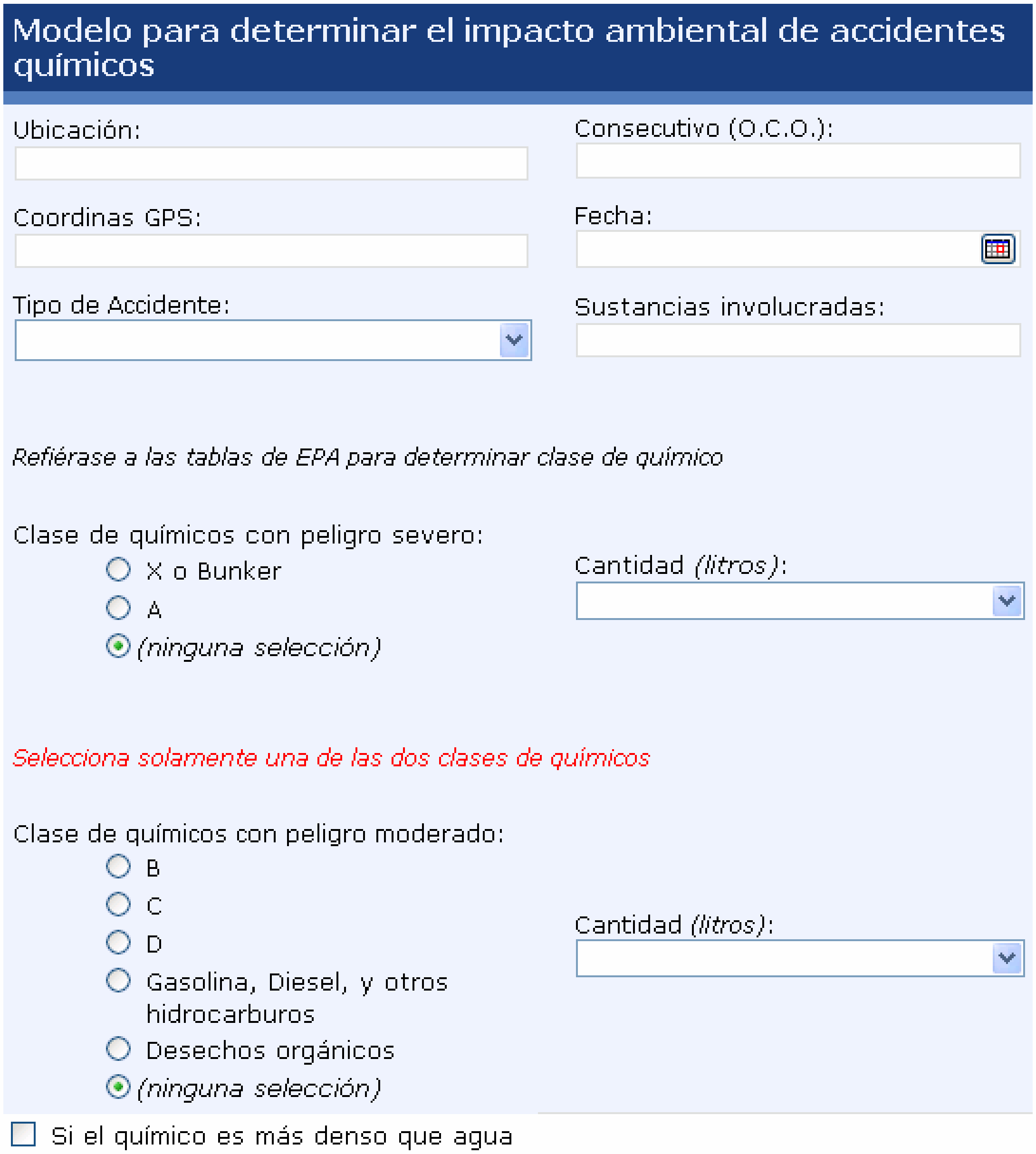
Después de tratar todos los detalles relevantes, el programa va a calcular automáticamente el impacto ambiental. Éste es mostrado abajo de la página.

Algunas veces, es posible que éste número exceda de 10, y eso indica claramente que el accidente fue de una gran escala.

Es posible crear una base de datos con ésta información. Puede guardar cada informe en un servidor central que alguien puede conseguir a cualquier momento.

Para más información o ayuda, no hesita de contactarnos a LosBomberos@wpi.edu

APPENDIX E – TEEICI


Modelo para determinar el impacto ambiental de accidentes químicos

Ubicación:

Consecutivo (O.C.O.):

Coordinas GPS:

Fecha:

Tipo de Accidente:

Sustancias involucradas:

Refiérase a las tablas de EPA para determinar clase de químico

Clase de químicos con peligro severo:

- X o Bunker
- A
- *(ninguna selección)*

Cantidad *(litros)*:

Selecciona solamente una de las dos clases de químicos

Clase de químicos con peligro moderado:

- B
- C
- D
- Gasolina, Diesel, y otros hidrocarburos
- Desechos orgánicos
- *(ninguna selección)*

Cantidad *(litros)*:

Si el químico es más denso que agua

Tipo de superficie

- ○ Pavimentada
- ○ Tierra húmeda
- ○ Arena/Tierra arenoso

Solamente en caso de gas

- ☐ Si el gas se dirige hacia bosques o reservas naturales

Velocidad de viento (kph):

Lluvia:

Ninguna lluvia

Agua

Ríos

- ☐ Si hay río o quebrada
- ☐ Si es agua estancada

Velocidad del agua (kph):

Mar

- ☐ Si contaminación es visible (en arena o agua)
- ☐ Si accidente es cerca de una población de especies protegidas
- ☐ Muerte de organismos marinos

Flora

- ☐ Si es una reserva natural
- ☐ Si hay bosque 2º
- ☐ Si las plantas queman o mueren instantáneamente

Área de suelo afectado (m^2):

Fauna

- ☐ Si es una especia protegida
- ☐ Si murieron peces
- ☐ Si unos animales mueren en un área no-cercada (animales silvestre)
- ☐ Si unos animales en una gran cantidad (20+) mueren en un área no-cercada
- ☐ Si unos animales mueren en un área cercada (animales domésticos)
- ☐ Si unos animales en una gran cantidad (20+) mueren en un área cercada

Impacto Ambiental: 0.0

Notas Opcional

Click here to insert

[Manda por Correo]

APPENDIX F – HERT

HERT- Human and Economical Ramification Tool

Location of Accident:___________

Chemical(s) released:_____________

Deaths/Life Threatening Injuries/Permanent Injury _____

1-5	+10
6-15	+20
16-25	+25
26-50	+35
51-75	+45
76-100	+50
101-125	+60
126-150	+70
151-175	+80
175+	+85

Non-Life Threatening Injuries _____

1-5	+5
6-15	+10
16-25	+15

26-50	+20
51-100	+25
101-150	+30
151-200	+35
201+	+40

Bomberos Injured or Killed ______

1-5	+10
6-10	+20
11-20	+30
21+	+40

Number of People Evacuated ______

1-20	+3
21-50	+6
51-100	+9
101-150	+12
151-200	+15
201-350	+18
351-500	+21
501-1000	+24
1001+	+27

(add 2 points for every day evacuated)

Drinking Water Contaminated ______

Each Additional Day	+2	
(Example: total of 4 for 1 day		
6 for 2 days)		

Number of Days Businesses Closed ______

1-3 Days	+2	
4-7 Days	+4	
7+	+6	

Value of Chemicals Leaked ______

5,000,000-15,000,000 colones	+3	
15,000,001-25,00,000 colones	+6	
>25,000,001 colones	+9	

Estimated Cost of Cleanup in ₡ ______

(even if none happened)

10,000,000-20,000,000	+3	
20,000,001-35,000,000	+6	
35,000,001-50,000,000	+9	
50,000,001-75,000,000	+12	
75,000,001+	+15	

Cost of Chemical Disposal in ₡ ______

5,000,000 – 10,000,000	+3
10,000,001+	+6

Property Damage in ₡ (structural) ______

1,000,000-5,000,000	+3
5,000,001-10,000,000	+6
10,000,001-20,000,000	+9
20,000,001-40,000,000	+12
40,000,001-60,000,000	+15
60,000,001+	+18

Property Damage in ₡ (cattle, vehicles, crops, other) ______

1,000,000-5,000,000	+3
5,000,001-10,000,000	+6
10,000,001-20,000,000	+9
20,000,001-40,000,000	+12
40,000,001-60,000,000	+15
60,000,001+	+18

Population Density (km^2) ______

1-20	+1
21-50	+3
51-100	+5
101-150	+7
151+	+9

Final Quantitative Number ______

APPENDIX G – Interview with Ana Lorena Arías

Environmental Engineer: Surá Soluciones Ambientales

June 2, 2005 (data collection techniques)

1. Is there a method in existence to evaluate environmental impact?

Various private consultants and student groups perform environmental impact studies. For example, Surá is in the process of doing an extensive study on river contamination throughout the country. This is not a simple evaluation method, but rather a compilation of various extensive analyses of the soil, water, and biology of the area in question. This research involves the help of various personnel with extensive backgrounds in environmental engineering, and multiple visits to each site in question.

The Costa Rican government collects information surrounding accidents but does not complete an impact statement in its entirety. It would be very difficult for the Bomberos to perform this type of analysis. Water and soil samples are very expensive and take fifteen days to analyze. The results of this analysis must be interpreted together with many other variables, such as the speed and turbulence of the water, characteristics of the soil present, weather patterns, and wildlife activity, to name only a few. The analysis utilizes a complicated and time-consuming calculation system that cannot be carried out without the proper training.

2. How can we evaluate the contamination in the air?

This is very difficult to determine after an accident has occurred because the gas has already dissipated. Analysis of air pollution is generally not done, and if so, is qualitative rather than quantitative.

3. How can we evaluate the contamination in the soil?

Several factors are considered when analyzing soil. Typically, Surá will take several samples from the area of contamination to determine the level of toxics that remain in the soil. There is a specific method to do this. Engineers must take one sample from the point where the spill has occurred. They must also take a control sample, far enough away from the spill that it reflects what the soil contained before contamination. Then, depending on the size and shape of the area, they will take a minimum of three more samples to determine the extent of the affected area. On the first trip, those taking the samples will begin by taking shallow samples in the area of contamination, carefully noting the locations of these samples. Once these results are analyzed, they will have the information they need to know where else samples should be taken. For instance, they may learn from the first samples that they must dig deeper in one area to obtain a true depth of contamination. They may also learn that the contamination is spread out into an area that they did not anticipate and that they must do additional tests on. A full analysis can take two or three return trips to the same area.

4. What is the correct process for sampling the soil?

A proper sample should be large enough not only to use in multiple tests, but also to ensure that it contains an accurate spectrum of the materials at that point. In order to be sure that the sample is large enough, engineers must dig a hole that is twenty centimeters wide, twenty centimeters long, and twenty centimeters deep. The soil from this pit must be mixed together thoroughly. The resulting pile must then be placed in a sealed bag and labeled carefully with the date, time, location, weather conditions, and any other pertinent observations. The sample taker should also label the bag with his or her name and record how deep the sample was taken.

5. How can we evaluate the contamination in the water?

Water samples are taken in a very similar manner as soil samples. One sample must be taken at the point of the accident and another upstream from the spill as a control. If the samples are being taken from the river, more samples should be taken at various distances from the point of contamination, at a minimum of three additional samples. In an area of stagnant water, samples should be taken in various places dependant on the shape and size of the body of water. Environmental engineers must first guess where to take water samples, and then reevaluate their choices upon receiving results of the sample analysis. For an area of complicated flow pattern, such an inlet, the optimal number of samples is closer to ten than to four.

6. What is the correct process for sampling the water?

The water must be collected in a large plastic bottle with a screw-on cap. The person taking the samples must first rinse out the bottle three times, each time filling it completely, shaking it, and then pouring the water back into the area of study. Once the bottle is rinsed, the sample taker then tips it slightly and submerges the bottle up to the top, leaving one side of the mouth of the bottle out of the water for air to escape. Rather than fill the bottle all the way to the top, it should be filled to a few centimeters below the mouth of the bottle. The person who gathered the sample then carefully labels each bottle with the location and date of the sample, his or her own name, and a number to identify the bottle and match it with its corresponding information sheet. The samples are then stored at a maximum of four degrees in transport to the laboratory.

In addition to collecting the actual samples, engineers at Surá also fill out an information sheet that corresponds with each bottle. This sheet includes the name of the sample taker, date and time of sample, GPS location, weather conditions, and several characteristics of the water itself. These factors are measured on site and filled into the sheet, such as velocity, pH, oxygen level, salinity, and temperature of the water. Investigators can determine the speed of the river by placing something buoyant in the water and timing how long it takes to travel a certain measured distance.

7. How can we measure affects to the local fauna?

This is very difficult to do because wild animals will most often run from an accident scene and will not appear in the vicinity when investigating engineers visit the area. Only the most obvious deceased or injured animals are available for observation or analysis. However, some animals can be a good indicator of contamination. If one digs into the soil at the scene of an accident, the presence of small red worms is a sign of pollution. Another sign would be if the area of suspected contamination appears to be free of wild animals such as birds when nearby areas are not the same. It is possible to take samples of fish from the water, but this is a very difficult process.

8. How can we measure affects to the local flora?

The effects on the plant life in a polluted area appear as discoloration of the leaves. In some areas, plants will be dead altogether. When studying water contamination, the presence of red, brown, or black moss on the rocks may be an indicator if the moss is green in other areas of the water. Much of the damage to plant life must be studied in comparison to nearby plant life that has not been damaged. These signs are usually clearly visible and easy to record with pictures and descriptions

9. What safety measures should we take in order to avoid contamination of our samples as well as to protect ourselves?

Anyone taking samples in a contaminated area should wear the proper safety gear. They should wear rubber gloves on their hands, boots that will not allow contamination to touch their bodies, and face masks where appropriate.

APPENDIX H – Interview with Ana Lorena Arias

Environmental Engineer: Surá, Soluciones Ambientales

June 22, 2005 (model refinement)

How can we improve the accuracy and depth of our evaluation tool?

Organic waste should be added as its own category because it can have very bad effects on the environment. This is because it tends to deplete the oxygen levels in water. The level of contamination is as high as that of hydrocarbons. Bunker should be given its own category of very high severity because it is worse for the environment than the other effects mentioned.

The presence of a river will increase the effect of a gas and should therefore be considered in our variables. There should be a range for the basic number that indicates whether or not the pollution effects are reversible, and whether or not this reversibility can be accomplished with or without human intervention. If the contamination is very low and likely to reverse itself, government officials should not bother taking samples. We should decide at what level samples are not necessary and indicate this in our model.

We should define the different types of animals in our analysis. For instance, we should define domestic, and research which species are protected in order for the Bomberos to be able to fill in this information.

Instead of relying solely on the EPA scale, it may be beneficial to research the categorization of chemicals used in some other nations, such as those in Europe, for comparison.

APPENDIX I – Interview with associate of Ana Lorena Arías

Environmental Engineer: Surá, Soluciones Ambientales

June 21, 2005

How can we improve the accuracy and depth of our evaluation tool?

There should be an area to enter weather details at the time of the accidents, most importantly, the level of precipitation. This effects where the contamination is carried as well as the speed at which it is absorbed into the soil. The wind speed and direction is important to note in order to determine where and how far the wind will carry escaped gases.

The type of surface is very important because concrete soil, sand, and other surfaces have different permeability and filtration characteristics that need to be considered. We should also indicate how far down a river the contamination has gone, just as we have indicated areas of soil contamination. Forest area should be split up into the two categories of rain forest and secondary forest.

Sewers should be included in the choices for bodies of water since they empty directly into the rivers. In places where there are tides, this movement of the water should be considered as it can wash contaminants back into the area they are being dispersed from. Other characteristics of rivers should also be considered, such as the inclination of the flow and dilution levels.

We should also decrease the base numbers, which only describe the type of chemical and amount, and raise all of the other factors in our model. If these numbers are disproportionate, we can be reflecting only the amount of chemical released rather than the actual affect it is having on the surrounding area.

The tool should be described further in a few different ways. It is apparent that this system can only be used within a certain window of time, and there should be a description of this limitation included in the instructions so that the tool is not used falsely. In addition, we should create or recommend the creation of a similar tool that can be used to study an accident site long after an accident has occurred. A companion human impact assessment would also be very helpful, and should include disposal and storage costs, equipment used, as well as the number of personnel who were necessary in the emergency response effort.

The final product should be complete with an instruction manual and justification for each variable ad its assigned value. In this way, the tool can stand on its own and be used by anyone who has access to the instructions.

APPENDIX J – Interview with Alvaro Coto, Environmental Manager, RECOPE – June 17, 2005

1. **How many facilities does RECOPE have operating in Costa Rica? How much oil does RECOPE process?**

There are seven facilities in operation in Costa Rica. A little less than five million liters are used each day. Twenty percent is processed in Limón, the other eighty percent is imported from other countries. Twenty-five percent of the clean product is sold for use by automobiles. The rest is used for airplanes and ships. The majority of this fuel is sent to airports in Santa Maria and Garita.

2. **How many accidents does RECOPE have every year?**

Last year there were five accidents, which is an unusually high number, two of which were leaks from processing plants and three of which were fuel lines broken by road crews. The leaks occurred in Garita and Cartago. Possibly more leaks in Limón are not on record in the Garita processing plant.

3. **What is the biggest accident that RECOPE has had?**

In 2004, there was a leak of fourteen thousand gallons in Heredia. A road repair crew punctured a pipeline with one of the pieces of machinery, causing a massive leak. Some areas of the country are equipped with two-meter high signs every fifty feet along the pipelines; however, there are many kilometers of pipe that are not marked at all. RECOPE has drawn maps of all of the pipelines in Costa Rica but road crews do not often use them. Last year, these maps were distributed to the government heads of all of the different provinces in Costa Rica. RECOPE held nine meetings with government officials as well as the Cruz Roja, Bomberos, municipalities, Comisión de Emergencias, and local emergency commissions from Puntarenas to Limón. A year later, three out of ten districts were using the maps. The others were not aware that they had the information or did not know where it was being stored.

4. Why is it that the road crews do not use the maps?

It is difficult to explain why road crews do not use the information that they have. There is little cooperation between organizations. They do as they wish without collaborating with other government municipalities. For MOPT[13], this means that they do not carry maps of the pipelines with them.

5. In the case of an oil spill, how do you respond?

Inside the RECOPE facility, there are means to clean up any oil spill that occurs. Anything that may happen outside of the facility is dealt with by the Bomberos. For instance, if there is an accident involving a RECOPE truck outside of the facility, RECOPE cannot treat the situation until the Bomberos arrive on the scene. However, all RECOPE trucks carry emergency equipment to deal with spills.

[13] Ministerio de Obras, Pública, y Transporte – Ministry of Public Works and Transport

If an accident occurs inside the facility, RECOPE can treat it until the Bomberos arrive and then they must hand over control of the scene immediately. RECOPE is equipped to manage any situation that may occur at the facility. A pool of water is stored on site, providing enough to fight a substantial fire in case one of the tanks was to ignite. It is constantly kept circulating by a system of hoses and filtered by tilapia fish that eat the contaminants. In case of a spill at the facility, they would fortunately know the identity of the chemical and would be able to treat the situation safely. The personnel at RECOPE would contain the spill with a barrier and try to remove some of gasoline with absorbents. RECOPE would then clean the soil.

If a pipeline is leaking, RECOPE must wait for the Bomberos before they can respond to the situation. When this occurs, RECOPE collaborates with the Bomberos.

6. Do you use bacteria to clean the soil?

This method is used, but only within the RECOPE facility. There is currently no information available as to the environmental impact of using such bacteria on gasoline or oil spills and an environmental study must be done before there is widespread use of this bacteria. Right now, RECOPE uses bacteria on small spills and has to enclose the spill completely before use. The majority of spills are cleaned by pumping away contaminants or absorbing them. Gasoline and kerosene disappear after two months on their own by evaporating.

However, diesel has a much bigger impact and takes longer to clean because it contains Benzene.

7. What preventative measures do you practice?

RECOPE can only guard against accidents at their facilities. Anything that occurs outside, such as highway accidents, is the responsibility of MINAE. All RECOPE tanks are equipped with an NFPA 704 label, number of tank, name of combustible, DOT flammability label, as well as a UN chemical identity number (CASRN). All RECOPE trucks are labeled with DOT labels and carry emergency instructions.

8. Are there laws dictatating the use of labels?

There are laws in place to use signage on all trucks and tanks, but the police do not enforce them. There are many laws that are not enforced. There is a thousand dollar fine for polluting a river that is rarely paid, if ever. Eighty percent of Costa Ricans think that they do not take adequate care in protecting the environment.

9. How many people work in Environmental Engineering for RECOPE?

There are six people working in environmental studies for RECOPE currently. They work in the areas of biology, forestry, geology, environmental impact and environmental education.

10. What should be considered when studying the severity of environmental impacts?

Soil water and vegetation damage should be studied primarily. Researchers should look for the presence of heavy metals, benzene, toluene, and hydrocarbons in samples. Water should be considered as a medium for the spread of contamination. This includes water in the soil, underground, and flowing above ground. Ecosystem damage should be looked at, including species populations and their effect on the food chain. Rivers will clean themselves quicker the faster they are flowing because flowing water helps to emulsify chemicals. The banks of the river, however, remain contaminated for longer.

RECOPE's priority is in people first, then the environmental, then their own facilities.

When looking at the animal population in the area, consider that most animals will move away from an accident site. However, in Costa Rica and other tropical climates, replenishment of species and soil quality is faster than in other climates.

11. How long does the natural cleanup process take?

If gasoline spills into the soil, it will be gone within two months with treatment. Without treatment, it will take three months. After forty five days, ninety percent of the fuel in soil will be destroyed if it is close to the surface. With no treatment effort, it can sink deeper underground and be there for centuries. A chemical like benzene will last even longer, perhaps for thousands of years.

12. How much does it cost to clean a contaminated area?

The cost to clean a gasoline spill is eight million dollars per acre in the United States, and fourteen million dollars per hectare in Costa Rica.

13. Where does RECOPE get its information regarding the environmental impact of chemical spills and cleanup procedures?

RECOPE receives training from PetroCanada as well as ChevronTexaco. They receive funding from Miami as members of Clean Caribbean. MINAE has its own classification system for chemicals.

14. How can we improve our own impact system?

Consider the ocean in the water contamination portion of the analysis. Also, be sure to remember that all sewers lead into the rivers and then the sea and so need to be considered. There should be a distinction between endangered and protected species, and this will need to be researched for the Bomberos. You should also distinguish between domestic and wild animals.

Bunker is very toxic and should be classified among the worst chemicals. Diesel should be categorized separately than gasoline because gasoline will evaporate quickly. We should also consider the depth of soil contamination and dilution levels in the water.

APPENDIX K – TRANSIT POLICE INTERVIEW

June 23, 2005

Data collected from the police was difficult to come by. Unlike the Bomberos, who have a large office building with computers for all of the employees, the transit police were clearly much shorter on funds. The police were headquartered in a small office building and were limited with technology such as computers.

Some of the questions we asked included the number of traffic tickets given out in any time span, number of accidents reported to the police, and the amount of revenue received by giving out speeding tickets and other driving infractions. The police had no statistics to offer us for any of these questions. We asked if anyone would know this type of information, and the police suggested that the people at social security might have the statistics we were looking for but were not sure.

Instead of giving us the statistics we desired, the police gave us some very basic information including the cost of speeding ticket and other laws that pertain to hazardous materials. A speeding ticket is five thousand colones at the base level, and going twenty kilometers per hour over the speed limit results in a twenty thousand colones fine. There are certain roads, such as the highway between the SJO international airport and downtown San José that trucks carrying hazardous materials are not allowed to travel on from the times of 7:00-

8:15 am and 4:00-6:30 pm. In addition, failure for paying traffic fines results in a thirty percent yearly interest rate.

The few laws and regulations that we heard about were encouraging information for us to hear, but the interview moved on to how these and other traffic laws are not strictly enforced. In Costa Rica, the police cannot collect traffic fines because too many citizens chose to not voluntary pay. Also, signage regulations are sometimes not closely followed by truckers, and will mislabel their vehicles either on purpose or for lack of care. We received no data showing how serious these issues really were, but the police gave the impression that they are commonplace.

APPENDIX L – Nosara Accident Report

Interview with Nicoya Bombero, Roy Herrera – June 8, 2005

1. **What was the cause of the accident?**

A farmer was trying to deparasite his cows and bought a container of Metafox (Remason 1211) to do this. He used five gallons on his cows before realizing that they were dying from the chemical. There are several ways this could have happened. Perhaps the Metafox mixed with another chemical in the area and reacted. Perhaps the dosage used by the farmer was too high. The chemical could also have been expired.

2. **How did you learn of the accident? How long did it take for you to respond?**

The incident occurred at 3:00 pm but they did not learn of it until they received a call at 5:00 pm. Two and a half hours later they arrived on the scene.

3. **How did you learn what chemical was involved? How much time did this take?**

Upon arrival at the farm, the farmer was able to tell them what substance he had been using and what had transpired.

4. How did you warn the public? How did you keep people from entering the affected area?

The police closed off the affected zone and evacuated the area. Forty people were evacuated for ten hours. One person was taken to the hospital.

5. What was the area of the affected zone?

The area was approximately forty square meters.

6. Are there wells in the area or sources of food such as farms?

There are wells in the area but they are not currently in use.

7. How did you clean the area? How much did this cost?

In this case, teh fire department did not do anything to clean the area. The chemical was left to soak into the ground.

8. Whose fault was this accident?

The farmers who had applied the chemical was Sr. Emerito Araya and one other person who worked on Sr. Araya's farm.

9. How many people were affected and in what way? Were there any injuries to Bomberos?

There was one person affected. The person who had applied the chemical with Sr. Araya was sent to the hospital in serious condition. No bomberos were injured or affected in any way. However there was a strong chemical smell at the accident scene and it was difficult to breathe.

10. How did the cows die in this instance?

The farmers were not aware that they were poisoning the cows until they were almost done applying the material, at which time the cows began to drop to the ground. They then called the fire department. All of the cows were put in one pile in the field and left there.

11. How much would it cost to replace the cows?

The cost of replacing all of the cows was approximately five million colones; ₡300,000 per cow and ₡ 1,000,000 per bull.

12. How many farms were affected?

No other farms were affected.

Interview with Sr. Emerito Araya – June 9, 2005

Sr. Araya bought the chemical in Nicoya from a veterinarian. This individual explained to him how to apply the chemical and how much to use. Sr. Araya and his son prepared the compound and painted it onto the backs of all of the cows. A few moments after application, the cows began head butting each other and dropping to the ground. Sr. Araya claimed that twenty-six cows died and their bodies had been put into two long pits, four meters deep and twenty meters wide, burned and then buried. He also claims that this product was used at another farm and killed forty-eight bulls. As it turns out, the chemical was actually an herbicide but was sold to him for application on his cows anyway. His son was hospitalized with severe respiratory problems and a loss of sphincter control. The son was put on a glucose drip for eight days.

There were soil samples taken by one of the ministries but Sr. Araya did not know what had been done with them. He asked that people be alerted about this chemical because nothing had been done to help him after his loss.

Interview with Nosara Police, Guanacaste – June 9, 2005

The police were the first to be on the scene, followed by the Ministerio de Salud and, lastly, the Bomberos. They reported a strong chemical smell in the area. The soil where the cows had been painted with the chemical was blue and green. Soil samples were taken by the Ministerio de Salud and analyzed, however the police were not informed of the results. There were no effects on the plants.

Interview with Ministerio de Salud – June 10, 2005

A representative from Ministerio de Salud refuted some of the facts that Sr. Araya had given to us. There is no report of any other incidents involving this chemical. Furthermore, only twenty-two cows were killed by the incident, as opposed to twenty-six. Ministerio de Salud determined that even though the bottle was clearly labeled, Sr. Araya and his son had made a mistake in their application because neither of them were literate. They could have bought the chemical more than a year prior to using it on the cows, surpassing the expiration date and increasing its toxicity.

PROGRAMA :SIBOP831
REPORTE :SIBOR831
USUARIO :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.
Detalle de Incidente

FECHA :
PAGINA :

INS

CONSECUTIVO:5619 29/02/2004
OPERADOR: Z-09

TIPO INCIDENTE: E-8 MATERIALES PELIGROSOS

CLASIFICACION: 14 MATERIAL PELIG. EN VIA PUBLICA

METODO DE AVISO: PERSONAL INF:

DIRECCION : NICOYA. NOSARA. BARRIO LOS ARENALES. FINCA EMERITO ARAYA.

ZONA : 502006 GUANACASTE NICOYA NOSARA-BIJAGUA
PERSONAL PERMANENTE: 0 VOLUNTARIO: 0

CRONOLOGIA

PA 17:47	5-4	M-F11	M-	M-	M-
SA	5-2	M-	M-	M-	M-
TA	5-3	M-	M-	M-	M-

ESCENA: 20:08 APLICACION: 00:00 CONTROLADO: 00:00 RETIRO: 21:47
EN BASE: 23:33 INSPECTORES: 00:00 AVISO CNFL: 00:00 DESCONEC: 00:00

DETALLE

INFORMA 7-24 QUE EN EL LUGAR, UNA PERSONA PREPARO UN COMPUESTO DE REMASON 1211, PARA DESPARASITAR GANADO. AL MOMENTO DEL DESPACHO APROXIMADAMENTE 30 RESES 7-28 Y TRASLADAN A UNA PERSONA EN ESTADO ROJO AL HOSPITAL DE LIBERIA.
SE LE INFORMA A D-1 Y D-2, D-5 NO CONTESTA.
INDICA 5-4 QUE INCIDENTE QUEDA A 57 KM DE LA ESTACION.
SEGUN DRA. ROJAS DEL CENTRO NACIONAL DE INTOXICACIONES EL PRODUCTO ES UN ORGANOFOSFORADO, CONOCIDO TAMBIEN METAFOX 60SL O PARACUA, INDICAN ALTAMENTE TOXICO, ABSOBERTE POR PIEL, CAUSA PROBLEMAS RESPIRATORIOS SEVEROS, DURA DE 2 A 3 HORAS ACTUANDO EN EL ORGANISMO Y SE RECOMIENDA EL USO DE TRAJE ENCAPSULADO TOTAL.
20:37 HRS. MANDO INFORMA, 22 RESES MUERTAS EL PRODUCTO FUE RECOGIDO POR LA G.A.R. EL PACIENTE INTOXICADO FUE TRASLADADO AL HOS PITAL. SE HIZO CONTACTO CON EL CTO.NAL. DE INTOXICACIONES. SE CONTACTO CON UN PERSONE RO DEL MINISTERIO DE SALUD. SE LE BRINDO

EL NUMERO TELEFONICO DE D-2.
21:47 HRS. MANDO INFORMA SE HIZO CONTACTO CON M.A.G. Y MINIST.SALUD, PARA SEGUIR PROCEDIMIENTOS EN EL SITIO, CON INDICACION DE D-2.
LA G.A.R. SE HACE CARGO DE LA ZONA YA QUE HAY PERSONAS QUE QUIEREN HACER PROCEDIMIEN TOS INADECUADOS. LA UNIDAD SE RETIRA.

*** ULTIMA LINEA ***

Reporte para Emergencias de Materiales Peligrosos **GPS__ zona 502006___**

Dirección de viento_---__ velocidad de viento (kph)_---__ temperatura de aire___---___

I. Ubicación:____Nosara___________ Fecha:__29 de Fev, 2004__

Tipo de Accidente:__Mat. Pel_____ Sustancias involucradas:_Metafox (Rimazinon)

Clase de química:_____X_________ __Organofosfora Diazinon_________________

Tipo de almacenamiento: ☐ Tanque ☐ Cisterna

☑ Estañones ☐ Envases ☐ Paquetes Volumen__5 gal._

II. *Si fue cisterna/vehiculo*

Empresa: ______________________ Conductor: ____________________________

Placa:_________________________ Revisión técnica al día:_________________

Señalizado:____________________ Portaba fichas de seguridad:_____________

Protocolo por matpel:____

III. *Si fue tanque -*

Ficha de seguridad ☐ Si ☐ No

Posición de la Válvula ☐ Abierta ☐ Cerrada

Capacidad ___________

Dique de retención ☐ Si ☐ No

Señalizado ☐ Si ☐ No

IV. *Control*

Contención:____________________ Transvasado:_________________________

Dilución:______________________ Encapsulamiento:_____________________

Personal involucrado:___________ Equipo Involucrado:_Policía, Bomberos____ Médicos, Ministerio de Salud

V. *Impacto Ambiental*

Personas afectadas

Civiles

Mujeres: Nº________ Edades: ______ Hombres: Nº___2____ Edades:________

Niñas: Nº________ Edades: ______ Niños: Nº________ Edades:________

Personal

Bomberos:Nº________ Edades: ______ Médicos: Nº________ Edades:________

Policía: Nº________ Edades: ______ Unid Matpel: Nº________ Edades: _______

Otros: Nº________ Edades: ______

Animales Afectados: ____22 vacas_________ Hay contaminación: ______________________

Contaminación del Aire: _______no________ (volumen en m^3):_______ ☑ mal olor

Contaminación del suelo: ______sí________ (área en m^2):____10______ ☑ color suelo *azul-verde*

Contaminación del agua: ______no________ ☐ Quebrada ☐ Pozos ☐ Laguna

☐ Río Distancia río abajo (en m): ________ ☐ Mar Área afectado (en m^2): ____________

☐ Otros Descripción: ____

Daños a la vegetación: no

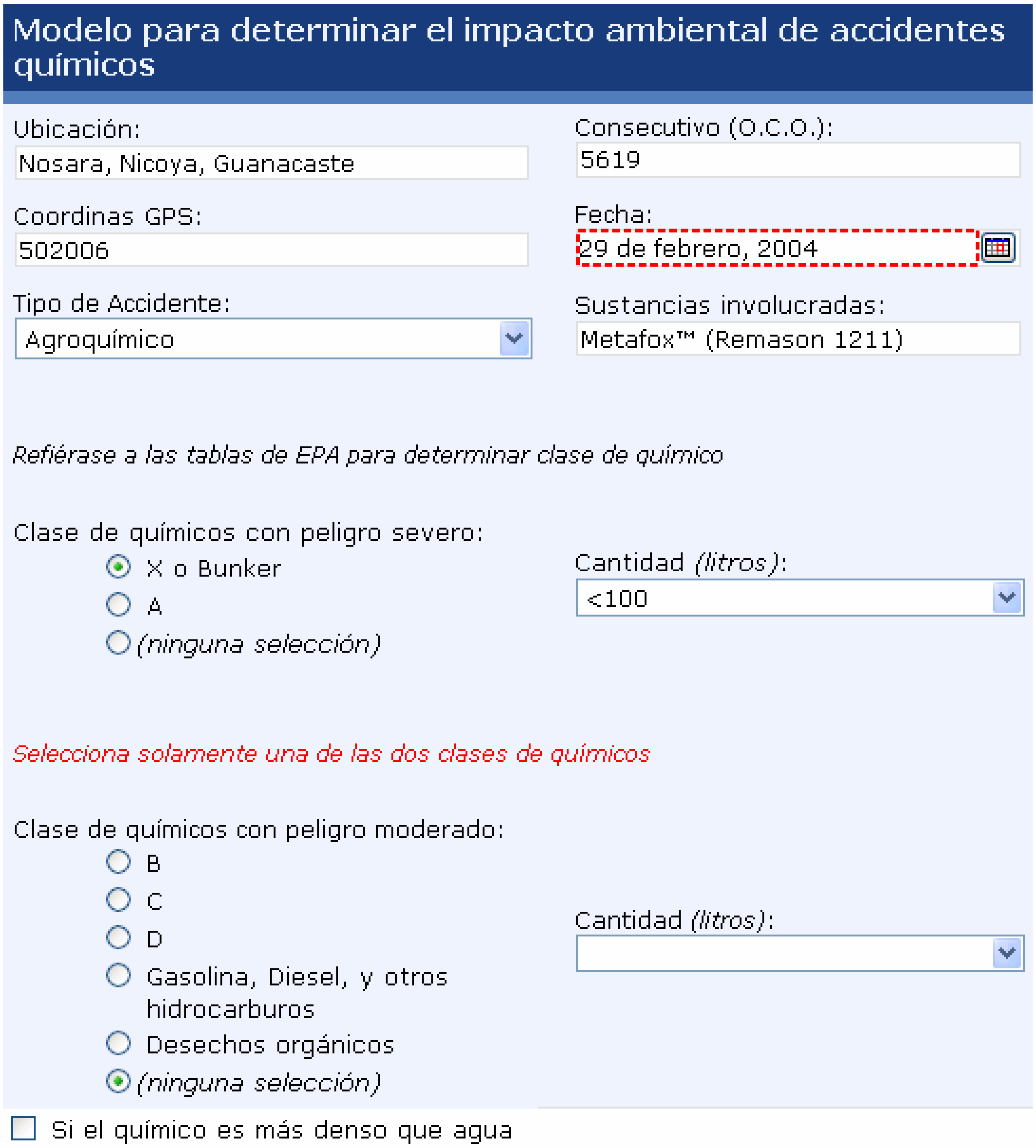
VI. Muestras: (condiciones, climatológicas, y hora recolección)

1. Suelo, en corral, seco, 13h 00

2. Suelo, en corral, seco, 13h 00

3. Suelo, control, lejos de corral (20m)

4. Lata de diazinon



Modelo para determinar el impacto ambiental de accidentes químicos

Ubicación: Nosara, Nicoya, Guanacaste

Consecutivo (O.C.O.): 5619

Coordinas GPS: 502006

Fecha: 29 de febrero, 2004

Tipo de Accidente: Agroquímico

Sustancias involucradas: Metafox™ (Remason 1211)

Refiérase a las tablas de EPA para determinar clase de químico

Clase de químicos con peligro severo:

- (•) X o Bunker
- ( ) A
- ( ) *(ninguna selección)*

Cantidad *(litros)*: <100

Selecciona solamente una de las dos clases de químicos

Clase de químicos con peligro moderado:

- ( ) B
- ( ) C
- ( ) D
- ( ) Gasolina, Diesel, y otros hidrocarburos
- ( ) Desechos orgánicos
- (•) *(ninguna selección)*

Cantidad *(litros)*:

☐ Si el químico es más denso que agua

Tipo de superficie	Solamente en caso de gas
○ Pavimentada ◉ Tierra húmeda ○ Arena/Tierra arenoso	☐ Si el gas se dirige hacia bosques o reservas naturales Velocidad de viento (kph): [ ] Lluvia: [Ninguna lluvia]

Agua

Ríos	Mar
☐ Si hay río o quebrada	☐ Si contaminación es visible (en arena o agua)
☐ Si es agua estancada	☐ Si accidente es cerca de una población de especies protegidas
Velocidad del agua (kph): [ ]	☐ Muerte de organismos marinos

Flora

☐ Si es una reserva natural	
☐ Si hay bosque 2°	Área de suelo afectado (m^2):
☐ Si las plantas queman o mueren instantáneamente	[< 500]

Fauna

- [ ] Si es una especia protegida
- [ ] Si murieron peces
- [ ] Si unos animales mueren en un área no-cercada (animales silvestre)
- [ ] Si unos animales en una gran cantidad (20+) mueren en un área no-cercada
- [x] Si unos animales mueren en un área cercada (animales domésticos)
- [x] Si unos animales en una gran cantidad (20+) mueren en un área cercada

Impacto Ambiental: 3.9

APPENDIX M – LA ESE

Interview with Pérez Zeledón Bomberos – June 14, 2005

1. **What was the cause of the accident?**

A tanker truck overturned on the highway. The driver had been speeding for a long time. As a result the brakes on the truck had become very hot and malfunctioned, causing the driver to lose control.

2. **How did you learn of the accident? How long did it take for you to respond?**

Someone called 911 and the fire fighters were there within fifteen minutes.

3. **How did you learn what chemical was involved? How much time did this take?**

The truck was carrying the appropriate labels and the driver was able to tell the fire department what he had been transporting.

4. **How did you warn the public? How did you keep people from entering the affected area?**

The police and fire department closed the highway and evacuated two nearby families.

5. What was the area of the affected zone?

All of the contents of the truck washed directly into a nearby ditch and so the affected area was very small. However, a stream developed later on in the same ditch, washing gasoline into nearby rivers and eventually to the ocean.

6. Are there wells in the area or sources of food such as farms?

There are no wells in the area but, much of the gasoline washed into nearby streams. These streams are only used for recreational use however.

7. How did you clean the area? How much did this cost?

The spill was contained with dikes and absorbed with soil and foam but they could not stop the contaminants from washing downstream.

8. Whose fault was this accident?

The driver had been speeding and therefore, was at fault in this case.

9. How many people were affected and in what way? Were there any injuries to Bomberos?

There were no people who were directly affected by this incident, but there was a large ecological affect.

10. How much was the lost gasoline worth?

The gasoline was worth ₡ 8,000,000

11. If you could do something different to improve this situation, what would it have been? Is there some equipment that you would have liked to have had?

It would be beneicial to have a hazardous materials unit available in the area but there aren't enough resources to do this.

Interview with the Instituto Costarricense de Acueductos y Alcantarillados (A y A) – June 15, 2005

1. **How many people were affected by this accident?**

The spill occurred downstream from one water treatment facility and so that facility was not affected at all. The water treatment facility downstream was closed off and as a result, no people could drink contaminated water form this facility.

2. **How did the water treatment plant respond to the spill?**

The facility asked the San José office of RECOPE, the oil company involved, to remove the contaminated soil in the area of the stream, but they refused de to the high cost. A soil sample was taken and sent to the A y A office in San José. Nothing further was done to respond to this spill.

3. **How do the local people know not to drink the water in such an incident?**

The spill is reported to the local government heads and then passed along to the citizens of the different areas by word of mouth.

4. How many people does the San Isidro water treatment facility supply with potable water?

There are approximately 100,000 people supplied with the water, which comes from the San Isidro treatment plant.

5. How many times does an accident of this type occur?

This type of accident is very rare. This was the first one that had occurred in the area in a number of years.

6. How is the water treated?

Water is allowed to enter large tanks at the facility where solids can settle to the bottom of the river. After this, the water is treated with chlorine and sent out into the acueducts. This chlorine is produced in Nicaragua. In the case of a gasoline spill, the company responsible must provide active carbon filters. There is twenty-four hour testing done on the water every day at the plant in order to monitor for contaminants.

7. What is the water in the rivers used for?

Water in the rivers is used for farming, fishing, drinking, and recreation.

8. Are there highways that run close to the water treatment facilities? What would you do if there were a spill directly into the water treatment facility?

The main highway runs directly by the A y A facility, however there is no plan in place for direct contamination of the rivers. There is a research project in progress to determine a better warning system for people who are using water that has become contaminated. There is always a certain level of contaminants that enters the water as runoff from the highways.

PROGRAMA :
EMISTE :
USUARIO :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.B.
Detalle de Incidente

FECHA :
PAGINA :

CONSECUTIVO: 22294 19/11/2004
OPERADOR: Z-10

TIPO INCIDENTE: E-8 MATERIALES PELIGROSOS

CLASIFICACION: 10 DERRAME COMBUST. EN CISTERNA

METODO DE AVISO: 914-8629 INF:

DIRECCION : PEREZ ZELEDON SAN RAFAEL NORTE

ZONA : 119001 SAN JOSE PEREZ ZELEDON SAN ISIDRO DEL GRL.
PERSONAL PERMANENTE: 8 VOLUNTARIO: 12

CRONOLOGIA

PA 16:18	1-7	M-019	M-R23	M-	M-
SA 16:42	1-9	M-S01	M-R18	M-	M-
TA	3-0	M-	M-	M-	M-

ESCENA: 16:23 APLICACION: 00:00 CONTROLADO: 20:15 RETIRO: 20:43
EN BASE: 21:00 INSPECTORES: 00:00 AVISO CNFL: 00:00 DESCONEC: 00:00

DETALLE

RESCATE-018 EN EL LUGAR A LAS 18:52 HRS
19:00 HRS SE TRANSFIERE EL MANDO A ALFA-02

VUELCO DE CISTERNA QUE TRANSPORTA DIESEL Y
GASOLINA REGULAR.
EL MISMO SE ESTA LLENDO POR UN AL
CANTARILLADO Y PUEDE AFECTAR UNA FUENTE DE
AGUA.
TRANSPOTA 8000 GALONES ENTRE DIESEL Y
GASOLINA.
PLACA DEL CABEZAL C-134028
CONDUCTOR OSCAR CASTRO JIMENEZ.
PROPIETARIO DEL CABEZAL: ALEX SANCHEZ.
379-5380.
DAÑOS: COSTADO DERECHO DEL CABEZAL.

Reporte para Emergencias de Materiales Peligrosos GPS__22294__

Dirección de viento_-----_ velocidad de viento (kph)_------_ temperatura de aire__------__

I. Ubicación:__San Isidro________ Fecha:_19 de Nov, 2004________

Tipo de Accidente:vuelco de camion Sustancias involucradas:__super gasolina, gasolina regular, diesel

Clase de química:__hidrocarburo ___

Tipo de almacenamiento: ☐ Tanque ☑ Cisterna

☐ Estañones ☐ Envases ☐ Paquetes Volumen_8000 gal._

II. *Si fue cisterna/vehiculo*

Empresa: ______Gasolinera Banía_ Conductor: __Oscar Castro Jiménez ______

Placa:___C-134028______________ Revisión técnica al día:_______sí__________

Señalizado:__________sí___________ Portaba fichas de seguridad:___sí________

Protocolo por matpel:__cordón - evacuate - diques________________________

III. *Si fue tanque -*

Ficha de seguridad ☐ Si ☐ No

Posición de la Válvula ☐ Abierta ☐ Cerrada

Capacidad ___________

Dique de retención ☐ Si ☐ No

Señalizado ☐ Si ☐ No

IV. *Control*

Contención:_______sí___________ Transvasado:_________________________

Dilución:_________________________ Encapsulamiento:_____________________

Personal involucrado:____________ Equipo Involucrado:_Bomberos, AyA, policía_

V. *Impacto Ambiental*

Personas afectadas

Civiles

Mujeres: Nº________ Edades: ______ Hombres: Nº________ Edades:________

Niñas: Nº________ Edades: ______ Niños: Nº________ Edades:________

Personal

Bomberos:Nº________ Edades: ______ Médicos: Nº________ Edades:________

Policía: Nº________ Edades: ______ Unid Matpel: Nº________ Edades: _______

Otros: Nº________ Edades: ______

Animales Afectados: ____________________ Hay contaminación: ________sí____________

Contaminación del Aire: _________________ (volumen en m^3):_______ ☑ mal olor

Contaminación del suelo: _______sí ________ (área en m^2):__________ ☐ color suelo

Contaminación del agua: _______sí ________ ☐ Quebrada ☐ Pozos ☐ Laguna

☑ Río Distancia río abajo (en m): _620 km + ☐ Mar Área afectado (en m^2): ____________

☐ Otros Descripción: ____

Daños a la vegetación: hay plantas muertas y dañadas

VI. Muestras: (condiciones, climatológicas, y hora recolección)

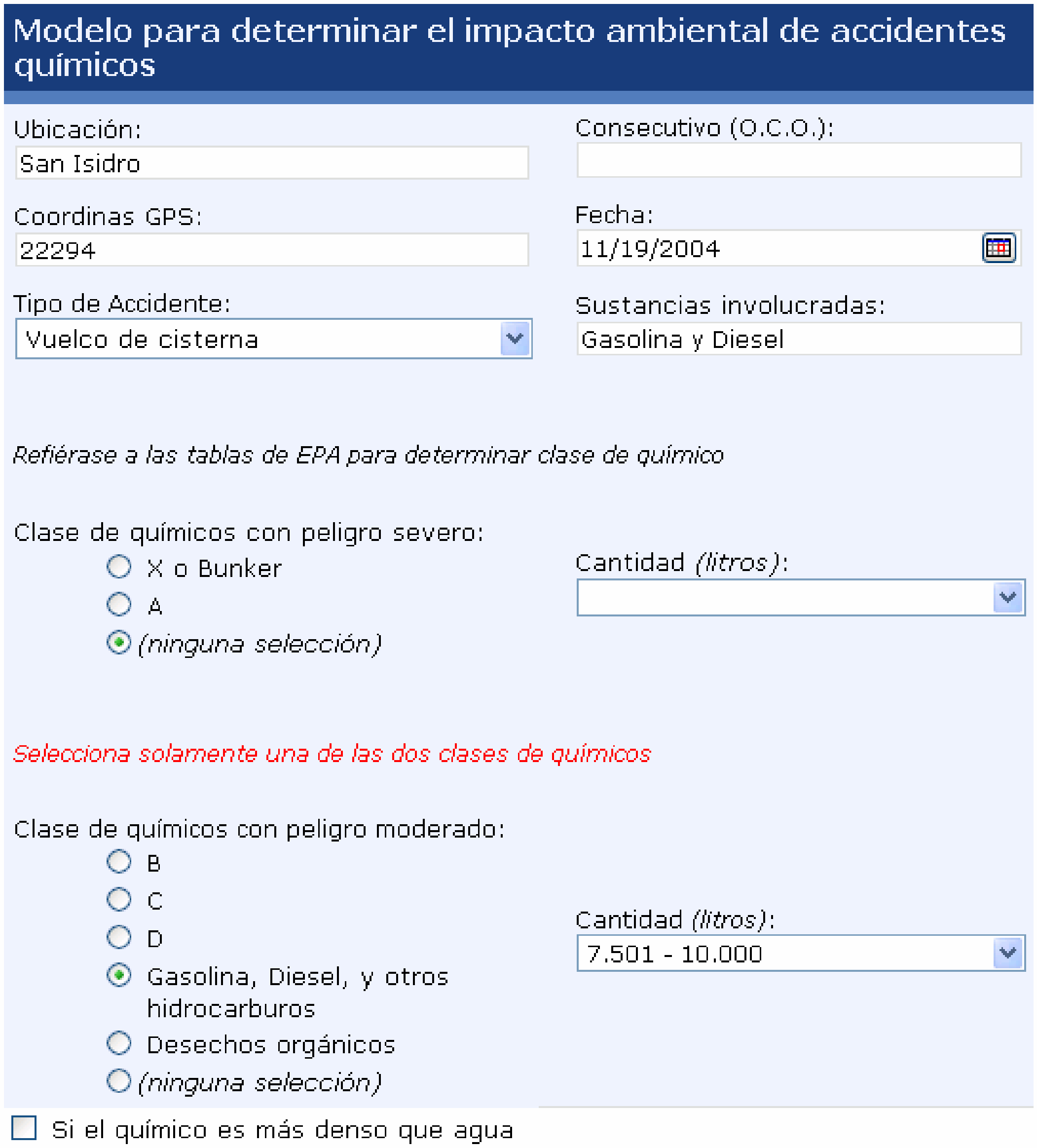
1.

2.

3.

4.

5.



Modelo para determinar el impacto ambiental de accidentes químicos

Ubicación:
San Isidro

Consecutivo (O.C.O.):

Coordinas GPS:
22294

Fecha:
11/19/2004

Tipo de Accidente:
Vuelco de cisterna

Sustancias involucradas:
Gasolina y Diesel

Refiérase a las tablas de EPA para determinar clase de químico

Clase de químicos con peligro severo:
- X o Bunker
- A
- *(ninguna selección)*

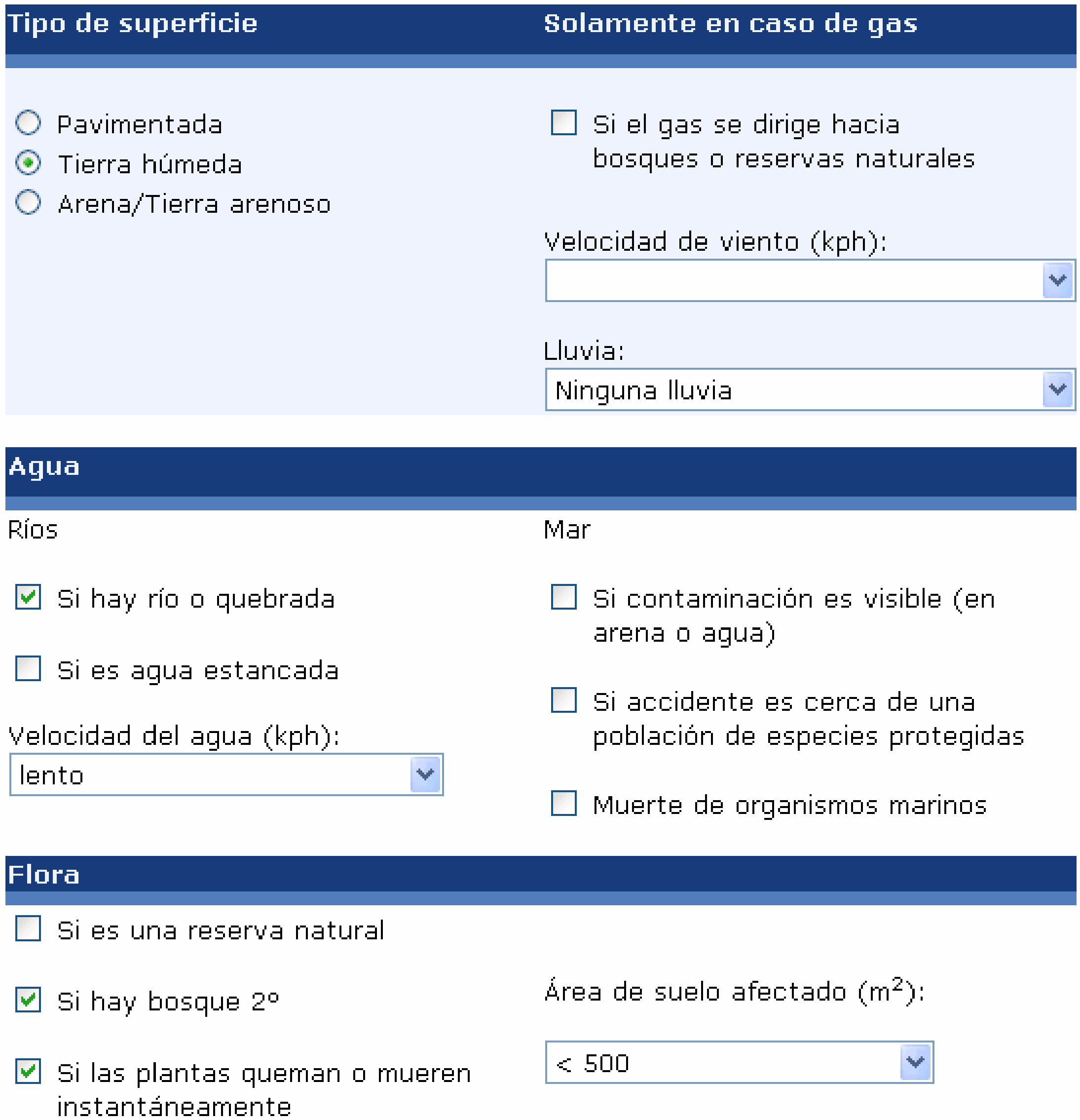
Cantidad *(litros)*:

Selecciona solamente una de las dos clases de químicos

Clase de químicos con peligro moderado:
- B
- C
- D
- Gasolina, Diesel, y otros hidrocarburos
- Desechos orgánicos
- *(ninguna selección)*

Cantidad *(litros)*:
7.501 - 10.000

Si el químico es más denso que agua



Tipo de superficie

- ( ) Pavimentada
- (•) Tierra húmeda
- ( ) Arena/Tierra arenoso

Solamente en caso de gas

- [ ] Si el gas se dirige hacia bosques o reservas naturales

Velocidad de viento (kph):

Lluvia: Ninguna lluvia

Agua

Ríos

- [x] Si hay río o quebrada
- [ ] Si es agua estancada

Velocidad del agua (kph): lento

Mar

- [ ] Si contaminación es visible (en arena o agua)
- [ ] Si accidente es cerca de una población de especies protegidas
- [ ] Muerte de organismos marinos

Flora

- [ ] Si es una reserva natural
- [x] Si hay bosque 2º
- [x] Si las plantas queman o mueren instantáneamente

Área de suelo afectado (m^2): < 500

Fauna

- ☐ Si es una especia protegida
- ☐ Si murieron peces
- ☐ Si unos animales mueren en un área no-cercada (animales silvestre)
- ☐ Si unos animales en una gran cantidad (20+) mueren en un área no-cercada
- ☐ Si unos animales mueren en un área cercada (animales domésticos)
- ☐ Si unos animales en una gran cantidad (20+) mueren en un área cercada

Impacto Ambiental: 5.1

Notas Opcional

Click here to insert

APPENDIX N – SAN ISIDRO

Interview with Pérez Zeledón Bomberos – 14, 2005

1. **What was the cause of the accident?**

A tanker truck overturned on the highway. The driver had been driving for almost two straight days and fallen asleep at the wheel of the vehicle, which subsequently veered out of control and off the highway.

2. **How did you learn of the accident? How long did it take for you to respond?**

The Cruz Roja called the Bomberos and they responded to the scene within twenty minutes.

3. **How did you learn what chemical was involved? How much time did this take?**

The truck was carrying the appropriate labels that indicated that the contents were flamable.

4. How did you warn the public? How did you keep people from entering the affected area?

There was no evacuation necessary because all of the contaminants had spilled into a nearby river. The area was closed off to the public and treated by the fire department.

5. What was the area of the affected zone?

The entire river was affected by the spill.

6. How did you clean the area? How much did this cost?

Nothing was done to clean the area by the fire department because there was already a natural dike at the point in the river where the spill took place and the presence of rain made it impossible to absorb the spill.

7. Whose fault was this accident?

The driver who had been sleeping was at fault. Unfortunately, he was injured in the accident and hosptalized.

1. How many people were affected and in what way? Were there any injuries to Bomberos?

There were no people who were directly affected by this incident, but there was a large ecological affect.

2. How much was the lost gasoline worth?

The gasoline was worth ₡ 6,000,000 in total. This breaks down to ₡ 394 per liter for gasoline and ₡ 286 per liter for diesel.

ROGRAMA :SIBOR?
EPORTE :SIBOREC1
SUARIO :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.
Detalle de Incidente

FECHA :
PAGINA :

INS

CONSECUTIVO: 18099 21/08/2004
OPERADOR: Z 04

TIPO INCIDENTE: F-5 MATERIALES PELIGROSOS

CLASIFICACION: 10 DERRAME COMBUST. EN CISTERNA

METODO DE AVISO: 771-3313 INF:

DIRECCION : CAJON DE PEREZ ZELEDON 20 KMS CARRETERA AL SUR

ZONA : 119008 SAN JOSE PEREZ ZELEDON CAJON-PARAISO-NUBES
PERSONAL PERMANENTE: 3 VOLUNTARIO: 0

CRONOLOGIA

PA	06:31	1-7	M-019	M-	M-	M-
SA		6-4	M-	M-	M-	M-
TA		3-0	M-	M-	M-	M-

ESCENA: 06:48 APLICACION: 00:00 CONTROLADO: 09:48 RETIRO: 14:08
EN BASE: 14:43 INSPECTORES: 00:00 AVISO CNFL: 00:00 DESCONEC: 00:00

DETALLE

REPORTAN VUELCO DE UN CISTERNA. MANDO
INFORMA: CISTERNA DERRAMANDO COMBUSTIBLE
HACIA UNA QUEBRADA.FUGA BASTANTE
GRANDE.TRATARAN DE CONTROLAR. CONDUCTOR YA
FUE LIBERADO.
LA DIRECCION ES: KM.151, RUTA 2.
INFORMADOS: A-1,A-2.
INFORMADO MARIO GONZALEZ EN C.N.E.
SE LE CONSULTA AL MANDO UN REPORTE DE PRO-
GRESO: INFORMA QUE SE DERRAMO UN 95% DEL
PRODUCTO EN LA QUEBRADA, EL RESTO LO
RECOGIERON LOS VECINOS Y SOBRE LA VIA.
COORDINA VAGONETA CON ARENA PARA HECHAR
SOBRE LA VIA Y GRUAS PARA LEVANTAR EL
CISTERNA.

08:15 ELMADO INDICA QUE SE DERRAMO:
21570LTS DE DIESEL.
9040LTS DE GASOLINA REGULAR.

08:20 SE CONTACTA A LOS DUEÑOS DEL
PRODUCTO SE DIRIGEN A LA ESCENA.
PROP. OVER SOLIS.
CHOFER: MINOR DELGADO JIMENEZ

Reporte para Emergencias de Materiales Peligrosos GPS__119008___

Dirección de viento__---__ velocidad de viento (kph)__---__ temperatura de aire___---____

I. Ubicación:__Pérez Zeledón________ Fecha:___21 de Ago, 2004______
Tipo de Accidente: vuelco de cisterna Sustancias involucradas:_diesel y gasolina regular
Clase de química:__hidrocarburo___ ______________________

Tipo de almacenamiento: ☐ Tanque ☑ Cisterna

☐ Estañones ☐ Envases ☐ Paquetes Volumen_30,000 L_

II. *Si fue cisterna/vehiculo*
Empresa: ___----------___________ Conductor: ____Minor Delgado Jiminez____
Placa:_____C133462____________ Revisión técnica al día:_________________
Señalizado:_______sí___________ Portaba fichas de seguridad:_____________
Protocolo por matpel:____

III. *Si fue tanque* -

Ficha de seguridad ☐ Si ☐ No

Posición de la Válvula ☐ Abierta ☐ Cerrada
Capacidad ___________

Dique de retención ☐ Si ☐ No

Señalizado ☐ Si ☐ No

IV. *Control*
Contención:__con diques_________ Transvasado:______________________
Dilución:__________________________ Encapsulamiento:___________________
Personal involucrado:___________ Equipo Involucrado:__Bomberos__________

V. *Impacto Ambiental*

Personas afectadas

Civiles

Mujeres: Nº________ Edades: ______ Hombres: Nº___1____ Edades:________
Niñas: Nº________ Edades: ______ Niños: Nº________ Edades:________

Personal

Bomberos:Nº________ Edades: ______ Médicos: Nº________ Edades:________
Policía: Nº________ Edades: ______ Unid Matpel: Nº________ Edades: _______
Otros: Nº________ Edades: ______

Animales Afectados: ____peses muertos____ Hay contaminación: ________sí____________

Contaminación del Aire: ________________ (volumen en m^3):_______ ☑ mal olor

Contaminación del suelo: _____sí_________ (área en m^2):___50___ ☑ color suelo

Contaminación del agua: ______sí_________ ☐ Quebrada ☐ Pozos ☐ Laguna

☑ Río Distancia río abajo (en m): _620 km+ ☐ Mar Área afectado (en m^2): ____________

☐ Otros Descripción: ____

Daños a la vegetación: hay plantas muertas y dañadas

VI. Muestras: (condiciones, climatológicas, y hora recolección)

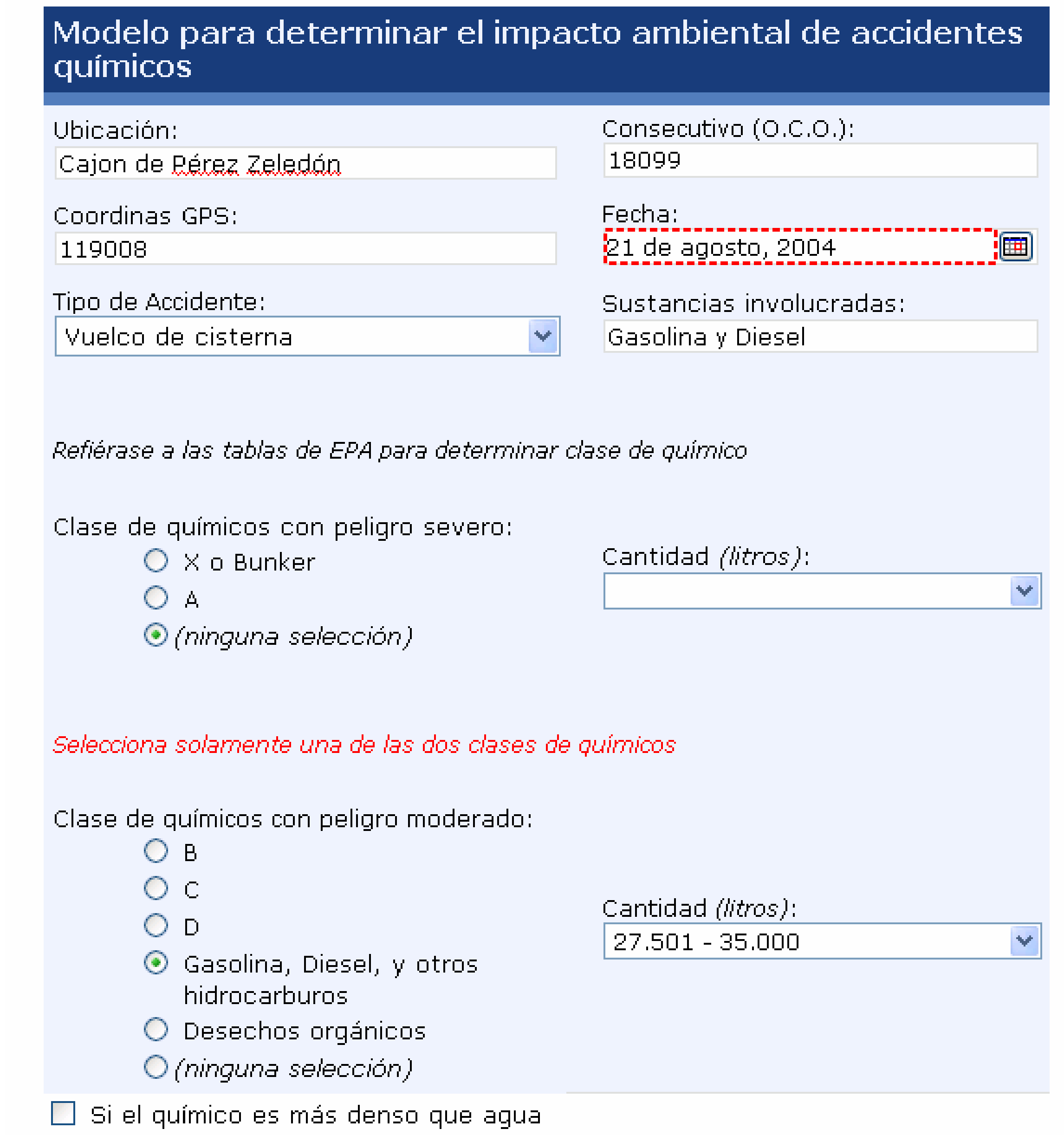
1.

2.

3.

4.

5.



Modelo para determinar el impacto ambiental de accidentes químicos

Ubicación: Cajon de Pérez Zeledón

Consecutivo (O.C.O.): 18099

Coordinas GPS: 119008

Fecha: 21 de agosto, 2004

Tipo de Accidente: Vuelco de cisterna

Sustancias involucradas: Gasolina y Diesel

Refiérase a las tablas de EPA para determinar clase de químico

Clase de químicos con peligro severo:

- ( ) X o Bunker
- ( ) A
- (•) *(ninguna selección)*

Cantidad *(litros)*:

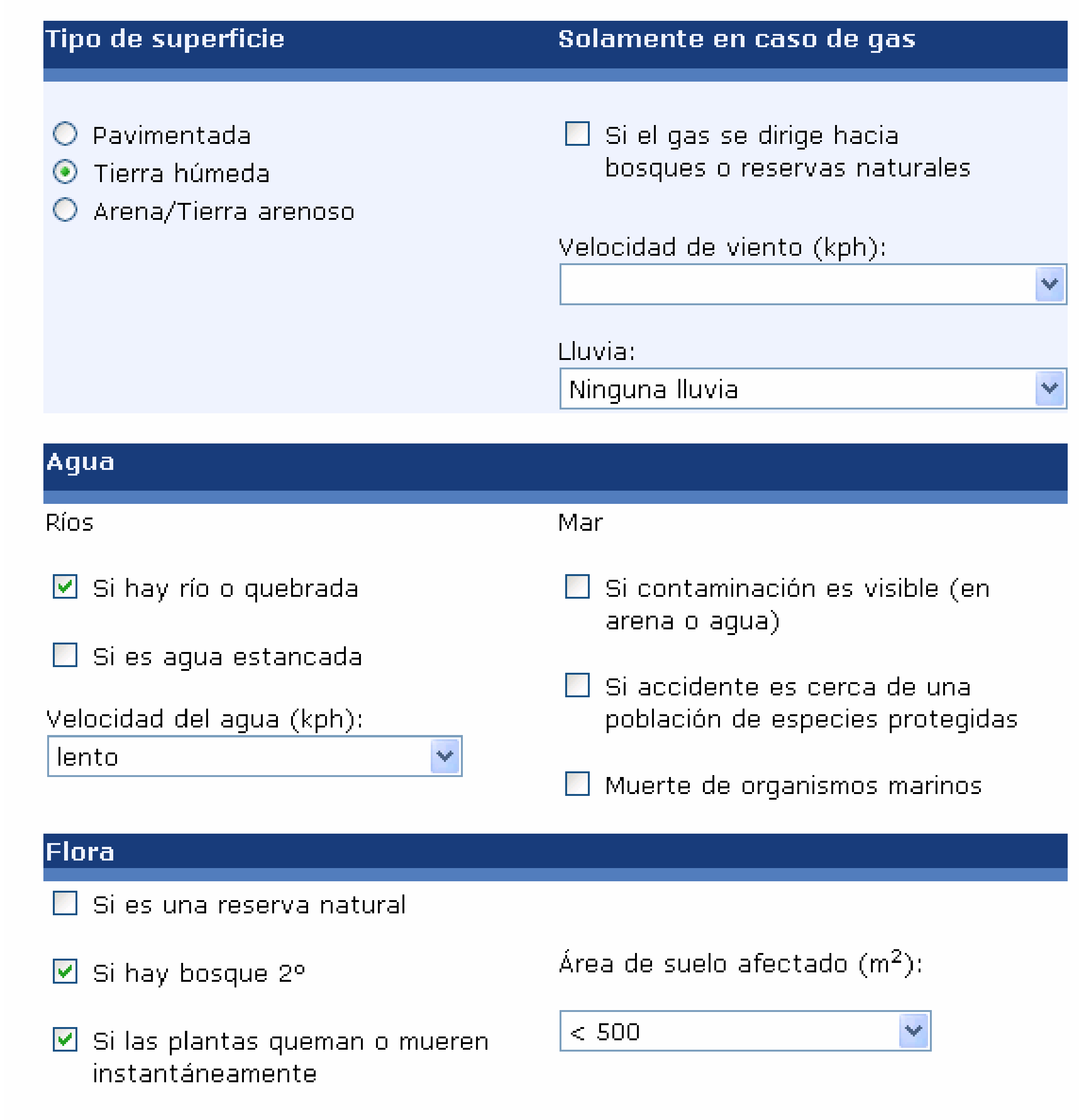
Selecciona solamente una de las dos clases de químicos

Clase de químicos con peligro moderado:

- ( ) B
- ( ) C
- ( ) D
- (•) Gasolina, Diesel, y otros hidrocarburos
- ( ) Desechos orgánicos
- ( ) *(ninguna selección)*

Cantidad *(litros)*: 27.501 - 35.000

☐ Si el químico es más denso que agua



Tipo de superficie

- ( ) Pavimentada
- (•) Tierra húmeda
- ( ) Arena/Tierra arenoso

Solamente en caso de gas

- [ ] Si el gas se dirige hacia bosques o reservas naturales

Velocidad de viento (kph):

Lluvia: Ninguna lluvia

Agua

Ríos

- [x] Si hay río o quebrada
- [ ] Si es agua estancada

Velocidad del agua (kph): lento

Mar

- [ ] Si contaminación es visible (en arena o agua)
- [ ] Si accidente es cerca de una población de especies protegidas
- [ ] Muerte de organismos marinos

Flora

- [ ] Si es una reserva natural
- [x] Si hay bosque 2°
- [x] Si las plantas queman o mueren instantáneamente

Área de suelo afectado (m^2): < 500

Fauna

- [ ] Si es una especia protegida
- [x] Si murieron peces
- [ ] Si unos animales mueren en un área no-cercada (animales silvestre)
- [ ] Si unos animales en una gran cantidad (20+) mueren en un área no-cercada
- [ ] Si unos animales mueren en un área cercada (animales domésticos)
- [ ] Si unos animales en una gran cantidad (20+) mueren en un área cercada

Impacto Ambiental: **8.1**

APPENDIX O – TOTAL GAS STATION, SAN JOSÉ

Interview with Tibás Bomberos – June 16, 2005

1. **What was the cause of the accident?**

An underground tank was leaking gasoline into the soil and streams surrounding the Total gas station. A suspected twenty thousand liters of gasoline was leaking. The tank is still underground.

2. **How did you learn of the accident?**

There were calls reporting a very strong smell of gasoline in the area of the gas station. The Bomberos responded, looking for a leak of combustibles so as to prevent an explosion. They found from tests done on the water in a stream that runs by the gas station that the ground had become very contaminated with gasoline and determined that there was an underground leak. This was done by coordinating with the National Commission of Emergencies.

3. **How did you learn what chemical was involved? How much time did this take?**

The details of this accident are still not complete. The leak could either be coming from one of two tanks or from the pipes that run between the tanks. The water nearby has been tested but was contaminated to bein with.

4. How did you warn the public? How did you keep people from entering the affected area?

There were thirty-five people evacuated from the area and taken to a shelter that is designated for this type of an emergency. They were given food and a place to sleep.

5. What was the area of the affected zone?

The affected area had a radius of about fifty meters.

6. Are there wells in the area or sources of food such as farms?

There are no wells in the area but much of the gasoline washed into nearby streams. There are three streams near the Total station that may have been affected.

7. How did you clean the area? How much did this cost?

The spill was contained with dikes and absorbed with soil and foam but they could not stop the contaminants from washing downstream. The soil should be rmoved but the scene is currently under control of the owner.

8. Whose fault was this accident?

The Total gas station is at fault in this case, but it was recently owned by another company. They should ideally be responsible for paying for the cleanup and evacuation of the area but have not yet been taken in front of the environmental tribunal.

9. How many people were affected and in what way? Were there any injuries to Bomberos?

Two people were treated for severe headaches at the hospital.

10. How much was the lost gasoline worth?

It is not yet clear how large this leak was.

11. If you could do something different to improve this situation, what would it have been? Is there some equipment that you would have liked to have had?

It would be very beneficial to have more advanced warning of ongoing chemical leaks such as this one. The public should know to call the fire department in case of such an accident.

Interview with Ministerio de Salud – June 17, 2005

The details of this accident are not completely known. The gasoline was leaking into the stream in two places. This lead the Ministerio de Salud to believe that there may be two tanks leaking chemicals into the ground. One tank is likely to be an actual fuel tank, and the other a septic tank that holds all of the toxic runoff from the station's drainage system. There could also be a leak in a pipe rather than a tank.

This gasoline station has been suspended from running since 2004 because it had failed to pass inspection. The underground tanks had failed to pass required tests such as pressure and hydrostatic tests, but the station had been operating without a license anyway. This station had been operating this way for two years prior as a Shell station. This was allowed to happen because the ministries do not have enough time to check on expired licenses. Often, there is no follow-up on such cases and the responsible companies ever have to pay for the damages or cost of cleanup. This station has caused additional problems, as the oil from the cars enters the stream each time the water table is high. The people in this area do not drink the water form the streams but will be affected if there is ay exposure to their skin.

Overall, there is not enough communication between organizations or follow-up on the prosecution of polluters. All of the ministries would benefit from sharing information, and this would make it easier to hold guilty parties accountable for their actions.

Reporte para Emergencias de Materiales Peligrosos **GPS__ 110001__**

Dirección de viento_-----_ velocidad de viento (kph)_-----_ temperatura de aire__-----___

I. Ubicación:___San José___________ Fecha:___6 de Jun, 2005_________

Tipo de Accidente:___derrame____ Sustancias involucradas:__gasolina____________

Clase de química:__hidrocarburo__ ____

Tipo de almacenamiento: ☑ Tanque ☐ Cisterna

☐ Estañones ☐ Envases ☐ Paquetes Volumen_20,000 gal

II. *Si fue cisterna/vehiculo*

Empresa: ______________________ Conductor: ___________________________

Placa:_________________________ Revisión técnica al día:__________________

Señalizado:_____________________ Portaba fichas de seguridad:_____________

Protocolo por matpel:____

III. *Si fue tanque* - ***no hay información a ese tiempo***

Ficha de seguridad ☐ Si ☐ No

Posición de la Válvula ☐ Abierta ☐ Cerrada

Capacidad ___________

Dique de retención ☐ Si ☐ No

Señalizado ☐ Si ☐ No

IV. *Control*

Contención:____________________ Transvasado:__________________________

Dilución:______________________ Encapsulamiento:______________________

Personal involucrado:____________ Equipo Involucrado: Bomberos, Com. Nat. de Emer., MINAE, Min. de Sal.

Impacto Ambiental

Personas afectadas

Civiles

Mujeres: Nº________ Edades: ______ Hombres: Nº___2____ Edades:________

Niñas: Nº________ Edades: ______ Niños: Nº________ Edades:________

Personal

Bomberos:Nº________ Edades: ______ Médicos: Nº________ Edades:________

Policía: Nº________ Edades: ______ Unid Matpel: Nº________ Edades: _______

Otros: Nº________ Edades: ______

Animales Afectados: ____________________ Hay contaminación: ________sí____________

Contaminación del Aire: ______sí__________ (volumen en m^3):_______ ☑ mal olor

Contaminación del suelo: _______sí_________ (área en m^2):____100____ ☐ color suelo

Contaminación del agua: ______sí__________ ☑ Quebrada ☐ Pozos ☐ Laguna

☐ Río Distancia río abajo (en m): ________ ☐ Mar Área afectado (en m^2): ___________

☐ Otros Descripción: ____

Daños a la vegetación: ____

____

____

____

V. Muestras: (condiciones, climatológicas, y hora recolección)

1.

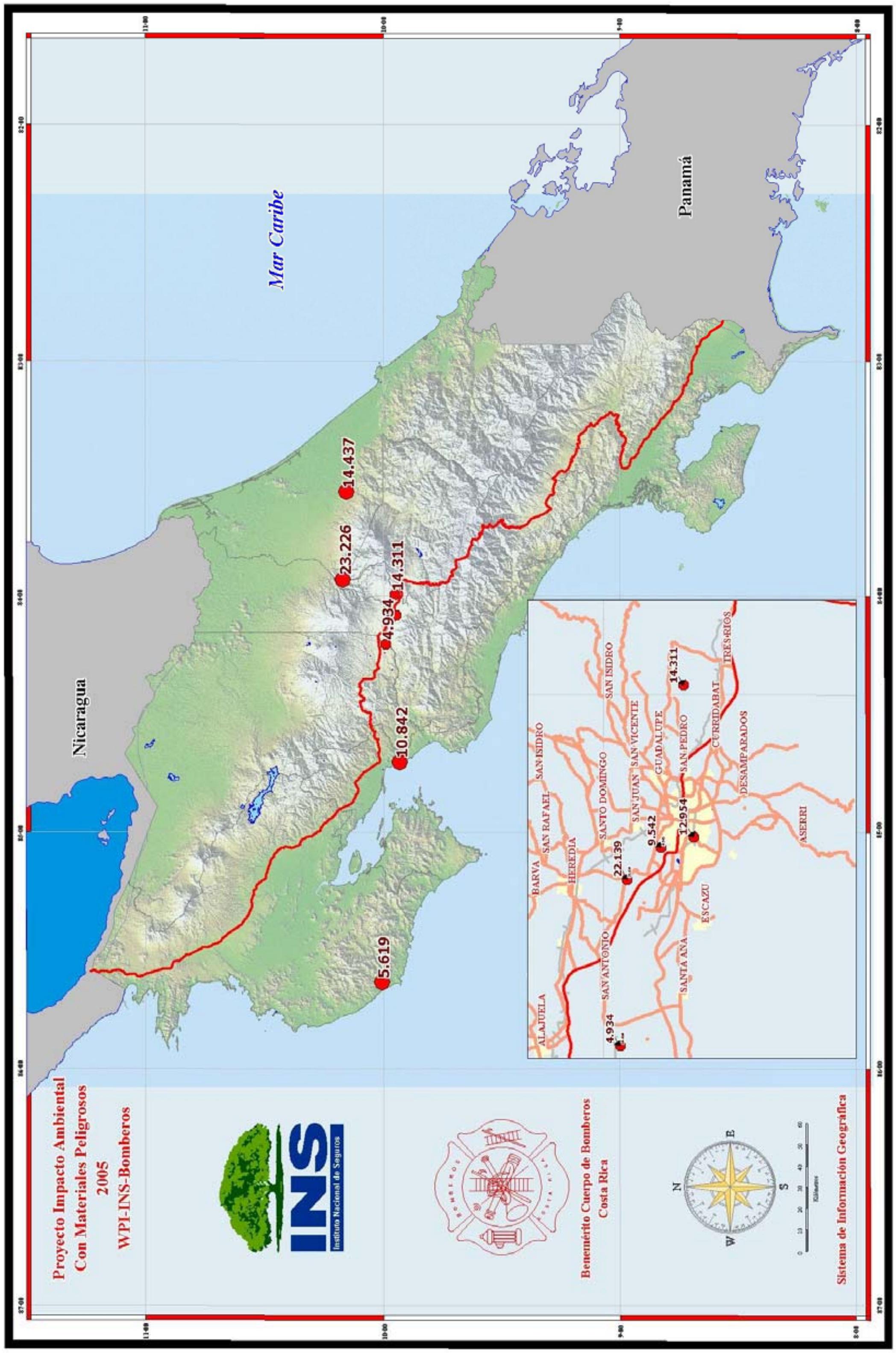
2.

3.

4.

5.

APPENDIX P – MAP OF COSTA RICA ACCIDENT SITES



APPENDIX Q – INS/OCO Raw Data about Accidents

PROGRAMA :SIBOP836
REPORTE :SIBOR836
USUARIO :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA :
PAGINA :

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2000 AL 31/12/2002

E-8	ESCAPE DE	:	
	1	. ESCAPE GASES EN RESIDENCIA	330
	10	. DERRAME COMBUST. EN CISTERNA	2
	11	. MATERIALES PELIG. RESIDENCIA	1
	12	. MALERIAL PELIG. EN INDUSTRIA	6
	14	. MATERIAL PELIG. EN VIA PUBLICA	12
	15	. MATERIAL PELIG. EN CISTERNA	3
	16	. ESCAPE GASES CENTROS MEDICOS	5
	17	. ESCAPE GAS CENTROS EDUCATIVOS	16
	2	. ESCAPE GASES EN COMERCIO	62
	3	. ESCAPE GASES EN INDUSTRIA	27
	4	. ESCAPE GASES EN VIA PUBLICA	10
	5	. ESCAPE GAS EN CAMION CISTERNA	3
	6	. DERRAME COMBUST. LIQ. INDUSTRI	1
	7	. DERRAME COMBUST. LIQ. RESIDENC	1
	8	. DERRAME COMBUST. LIQ. COMERCIO	4
	9	. DERRAME COMBUST. VIA PUBLICA	5
SUBTOTAL :			488

PROGRAMA :SIBOP836
REPORTE :SIBOR836
USUARIO :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA :
PAGINA :

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2001 AL 31/12/2001

E-8	ESCAPE DE	:	
	1	. ESCAPE GASES EN RESIDENCIA	329
	10	. DERRAME COMBUST. EN CISTERNA	2
	11	. MATERIALES PELIG. RESIDENCIA	2
	12	. MALERIAL PELIG. EN INDUSTRIA	9
	13	. MATERIAL PELIG. EN COMERCIO	2
	14	. MATERIAL PELIG. EN VIA PUBLICA	3
	15	. MATERIAL PELIG. EN CISTERNA	2
	16	. ESCAPE GASES CENTROS MEDICOS	2
	17	. ESCAPE GAS CENTROS EDUCATIVOS	9
	18	. MATRIAL PELIG. CENTROS EDUCAT.	2
	2	. ESCAPE GASES EN COMERCIO	72
	20	. ESCAPE GAS CENTRO RELIGIOSO	1
	22	. AGENTES BACTEREOLOGICOS	127
	3	. ESCAPE GASES EN INDUSTRIA	32
	4	. ESCAPE GASES EN VIA PUBLICA	5
	5	. ESCAPE GAS EN CAMION CISTERNA	3
	6	. DERRAME COMBUST. LIQ. INDUSTRI	4
	8	. DERRAME COMBUST. LIQ. COMERCIO	2
	9	. DERRAME COMBUST. VIA PUBLICA	15
SUBTOTAL :			623
TOTAL GENERAL:			623

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA :
PAGINA :

INS

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2002 AL 31/12/2002

E-8 MATERIALES PELIGROSOS :

1 . ESCAPE GASES EN RESIDENCIA	502
10. DERRAME COMBUST. EN CISTERNA	2
11. MATERIALES PELIG. RESIDENCIA	4
12. MALERIAL PELIG. EN INDUSTRIA	9
13. MATERIAL PELIG. EN COMERCIO	6
14. MATERIAL PELIG. EN VIA PUBLICA	15
16. ESCAPE GASES CENTROS MEDICOS	2
17. ESCAPE GAS CENTROS EDUCATIVOS	19
18. MATRIAL PELIG. CENTROS EDUCAT.	1
2 . ESCAPE GASES EN COMERCIO	91
21. DERRAME EN POLIDUCTO	6
22. AGENTES BACTEREOLOGICOS	7
3 . ESCAPE GASES EN INDUSTRIA	30
4 . ESCAPE GASES EN VIA PUBLICA	18
5 . ESCAPE GAS EN CAMION CISTERNA	4
6 . DERRAME COMBUST. LIQ. INDUSTRI	7
7 . DERRAME COMBUST. LIQ. RESIDENC	1
8 . DERRAME COMBUST. LIQ. COMERCIO	3
9 . DERRAME COMBUST. VIA PUBLICA	11
SUBTOTAL :	738

[illegible]:SIBOP836
[illegible]:SIBOR836
[illegible] :

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA :
PAGINA :

INS

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2003 AL 31/12/2003

E-8 MATERIALES PELIGROSOS :

1 . ESCAPE GASES EN RESIDENCIA	609
10. DERRAME COMBUST. EN CISTERNA	4
11. MATERIALES PELIG. RESIDENCIA	4
12. MALERIAL PELIG. EN INDUSTRIA	17
13. MATERIAL PELIG. EN COMERCIO	1
14. MATERIAL PELIG. EN VIA PUBLICA	7
15. MATERIAL PELIG. EN CISTERNA	1
16. ESCAPE GASES CENTROS MEDICOS	5
17. ESCAPE GAS CENTROS EDUCATIVOS	13
2 . ESCAPE GASES EN COMERCIO	92
20. ESCAPE GAS CENTRO RELIGIOSO	5
21. DERRAME EN POLIDUCTO	1
22. AGENTES BACTEREOLOGICOS	2
3 . ESCAPE GASES EN INDUSTRIA	41
4 . ESCAPE GASES EN VIA PUBLICA	9
5 . ESCAPE GAS EN CAMION CISTERNA	3
6 . DERRAME COMBUST. LIQ. INDUSTRI	3
8 . DERRAME COMBUST. LIQ. COMERCIO	2
9 . DERRAME COMBUST. VIA PUBLICA	8
SUBTOTAL :	827
TOTAL GENERAL:	827

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2004 AL 31/12/2004

E-8	MATERIALES PELIGROSOS :	
	1 . ESCAPE GASES EN RESIDENCIA	171
	11. MATERIALES PELIG. RESIDENCIA	1
	12. MALERIAL PELIG. EN INDUSTRIA	3
	13. MATERIAL PELIG. EN COMERCIO	1
	14. MATERIAL PELIG. EN VIA PUBLICA	4
	16. ESCAPE GASES CENTROS MEDICOS	2
	17. ESCAPE GAS CENTROS EDUCATIVOS	4
	2 . ESCAPE GASES EN COMERCIO	22
	21. DERRAME EN POLIDUCTO	1
	3 . ESCAPE GASES EN INDUSTRIA	8
	4 . ESCAPE GASES EN VIA PUBLICA	3
	5 . ESCAPE GAS EN CAMION CISTERNA	4
SUBTOTAL :		224
TOTAL GENERAL:		224

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2004 AL 31/12/2004

E-8	MATERIALES PELIGROSOS :	
	1 . ESCAPE GASES EN RESIDENCIA	372
	10. DERRAME COMBUST. EN CISTERNA	6
	11. MATERIALES PELIG. RESIDENCIA	2
	12. MALERIAL PELIG. EN INDUSTRIA	9
	13. MATERIAL PELIG. EN COMERCIO	5
	14. MATERIAL PELIG. EN VIA PUBLICA	7
	15. MATERIAL PELIG. EN CISTERNA	3
	16. ESCAPE GASES CENTROS MEDICOS	3
	17. ESCAPE GAS CENTROS EDUCATIVOS	14
	18. MATRIAL PELIG. CENTROS EDUCAT.	4
	2 . ESCAPE GASES EN COMERCIO	53
	20. ESCAPE GAS CENTRO RELIGIOSO	1
	21. DERRAME EN POLIDUCTO	1
	3 . ESCAPE GASES EN INDUSTRIA	13
	4 . ESCAPE GASES EN VIA PUBLICA	4
	5 . ESCAPE GAS EN CAMION CISTERNA	4
	6 . DERRAME COMBUST. LIQ. INDUSTRI	4
	8 . DERRAME COMBUST. LIQ. COMERCIO	3
	9 . DERRAME COMBUST. VIA PUBLICA	7
SUBTOTAL :		515

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

INS

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2005 AL 17/5/2005

E-15 MATERIALES PELIGROSOS :	
1 . AMONIACO	3
12. DIOXIDO DE CARBONO CO2	1
13. MATERIAL PELIGROSO	6
15. DERRAME COMBUSTIBLE CISTERNA	1
16. DERRAME COMBUSTIBLE	2
2 . CLORO	5
3 . AGROQUIMICO	6
5 . ACIDO SULFURICO	1
SUBTOTAL :	25

ROGRAMA :SIBOP836
EPORTE :SIBOR836
SUARIO :07

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA :
PAGINA :

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2005 AL 18/5/2005

E-15 MATERIALES PELIGROSOS :	
1 . AMONIACO	3
12. DIOXIDO DE CARBONO CO2	1
13. MATERIAL PELIGROSO	7
15. DERRAME COMBUSTIBLE CISTERNA	1
16. DERRAME COMBUSTIBLE	2
2 . CLORO	5
3 . AGROQUIMICO	6
5 . ACIDO SULFURICO	1
SUBTOTAL :	26
TOTAL GENERAL:	26

ROGRAMA :SIBOP836
EPORTE :SIBOR836
SUARIO :07

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA : 18/05/2005
PAGINA : 1

AREA: TODO EL PAIS
ESTACION: TODO EL PAIS
DEL 1/1/2005 AL 18/5/2005

E-8 ESCAPES DE GAS LPG :	
1 . ESCAPE GASES EN RESIDENCIA	187
2 . ESCAPE GASES EN COMERCIO	25
3 . ESCAPE GASES EN INDUSTRIA	2
4 . ESCAPE GASES EN VIA PUBLICA	6
5 . ESCAPE GASES CENTROS MEDICOS	1
6 . ESCAPE GAS CENTROS EDUCATIVOS	2
SUBTOTAL :	223
TOTAL GENERAL:	223

PROGRAMA :SIBOP832
REPORTE :SIBOR832
USUARIO :07
ESTADISTICA:

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA : 18
PAGINA :

DEL 01/01/2005 AL 18/05/2005

INCIDENTE	ESTACION	ZONA	FECHA	OPERADOR	CONSEC.	P.A.	S.A.	T.A.	ESC	APL	CON	RET	BAS	1º U.	2º U.
-15 2	3-4	303001	17/01/2005	Z-05	1193	11:28	11:29	11:29	11:37	00:00	11:47	13:16	13:23	M-053	
						200 NORTE SUCURSAL B.C.A.C TRES RIOS									
-15 13	2-2	205001	02/02/2005	Z-16	2697	08:53	09:01		09:05	00:00	12:21	12:21	12:40	M-080	
						ATENAS RIO GRANDE SEBADILLA CARRETERA NUEVA A CALDERA									
-15 3	1-6	104001	03/02/2005	Z-50	2900	20:29			20:38	00:00	00:42	00:42	00:45	M-034	
						SAN JOSE, PURISCAL URBANIZACIO N SANTIAGO.									
-15 15	6-6	605002	18/02/2005	Z-05	4586	23:37	00:46		00:02	00:00	04:30	05:05	05:45	M-R24	
						PUNT. PALMAR NORTE 12 KMS HACI A BUENOS AIRES.									
-15 13	8-0	701001	19/02/2005	Z-16	4671	18:30	19:59	19:08	18:33	00:00	23:08	23:25	23:36	M-031	M-091
						LIMON HOSPITAL TONY FACIO									
-15 13	3-0	301001	01/03/2005	Z-16	5722	10:30	10:56	11:15	10:56	00:00	19:42	19:42	21:19	M-059	
						TEJAR DEL GUARCO DEL PARQUE 500 S									
-15 12	4-0	408001	22/04/2005	Z-09	10732	23:57	00:17		00:07	00:00	00:31	01:09	01:16	M-025	
						SAN JOAGUIN DE FLORES 300 E DE LA CERVECERIA									
-15 3	6-8	601008	03/05/2005	Z-15	11667	10:14	10:18	10:28	10:27	12:31	21:14	22:28	22:50	M-090	
						PTNAS. CALDERA PREDIO DE M Y M									
-15 1	1-3	115001	11/05/2005	Z-05	12230	10:40	10:40	10:40	10:46	00:00	12:45	14:00	14:20	M-092	
						S.J, MONTES DE OCA UCR, DETRAS FACULTAD DE FARMACIA.									
-15 3	6-8	602001	13/05/2005	Z-15	12371	17:30	19:09	20:15	17:45	00:00	01:41	02:00	02:16	M-090	
						CALDERA EN CONTENEDORES CAL- DERA.									

ROGRAMA :SIBOP832
EPORTE :SIBOR832
UARIO :07
STADISTICA:

INSTITUTO NACIONAL DE SEGUROS
CUERPO DE BOMBEROS DE COSTA RICA
OFICINA DE COMUNICACIONES O.C.O.

FECHA : 18
PAGINA : 1

DEL 01/01/2005 AL 18/05/2005

INCIDENTE	ESTACION	ZONA	FECHA	OPERADOR	CONSEC.	P.A.	S.A.	T.A.	ESC	APL	CON	RET	BAS	1º U.	2º U.
-8 1	1-3	115002	31/01/2005	Z-02	2544	14:23	14:35		14:33	00:00	15:03	15:08	15:48	M-092	
						MONTES OCA CEDROS TABERNA CORSARIO									
-8 1	1-12	109001	26/02/2005	Z-10	5381	13:10			13:16	00:00	13:32	13:32	13:43	M-051	
						SANTA ANA DE LA CRUZ ROJA 500 ESTE,125 SUR.									
-8 4	3-5	302001	07/05/2005	Z-15	12026	16:20	16:22	16:34	16:29	00:00	09:38	12:21	13:02	M-052	
						CARTAGO.PARAISO, BIRRISITO 1 KM. HACIA CERVANTES									

*** ULTIMA LINEA ***

TOTAL DE INCIDENTES: 3

APPENDIX R – SAMPLE OF EPA REPORTALE QUANTITY SCALE

TABLE 302.4—LIST OF HAZARDOUS SUBSTANCES AND REPORTABLE QUANTITIES

[Note: All Comments/Notes Are Located at the End of This Table]

Hazardous substance	CASRN	Regulatory synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA waste Number	Category	Pounds (Kg)
Acenaphthene	83329		1*	2		B	100 (45.4)
Acenaphthylene	208968		1*	2		D	5000 (2270)
Acetaldehyde	75070	Ethanal	1000	1,3,4	U001	C	1000 (454)
Acetaldehyde, chloro-	107200	Chloroacetaldehyde	1*	4	P023	C	1000 (454)
Acetaldehyde, trichloro-	75876	Chloral	1*	4	U034	D	5000 (2270)
Acetamide	60355		1*	3		B	100 (45.4)
Acetamide, N-(aminothioxomethyl)-	591082	1-Acetyl-2-thiourea	1*	4	P002	C	1000 (454)
Acetamide, N-(4-ethoxyphenyl)-	62442	Phenacetin	1*	4	U187	B	100 (45.4)
Acetamide, 2-fluoro-	640197	Fluoroacetamide	1*	4	P057	B	100 (45.4)
Acetamide, N-9H-fluoren-2-yl-	53963	2-Acetylaminofluorene	1*	3,4	U005	X	1 (0.454)
Acetic acid	64197		1000	1		D	5000 (2270)
Acetic acid (2,4-dichlorophenoxy)-, salts & esters	94757	2,4-D Acid, 2,4-D,salts and esters	100	1,3,4	U240	B	100 (45.4)
Acetic acid, Lead(2+) salt	301042	Lead acetate	5000	1,4	U144	A	10 (4.54)
Acetic acid, thallium (1+) salt	563688	Thallium(I) acetate	1*	4	U214	B	100 (45.4)
Acetic acid, (2,4,5-trichlorophenoxy)	93765	2,4,5-T 2,4,5-T acid	100	1,4	U232	C	1000 (454)
Acetic acid, ethyl ester	141786	Ethyl acetate	1*	4	U112	D	5000 (2270)
Acetic acid, fluoro-, sodium salt	62748	Fluoroacetic acid, sodium salt	1*	4	P058	A	10 (4.54)
Acetic anhydride	108247		1000	1		D	5000 (2270)
Acetone	67641	2-Propanone	1*	4	U002	D	5000 (2270)
Acetone cyanohydrin	75865	Propanenitrile, 2-hydroxy-2-methyl-2-Methyllactonitrile.	10	1,4	P069	A	10 (4.54)
Acetonitrile	75058		1*	3,4	U003	D	5000 (2270)
Acetophenone	98862	Ethanone, 1-phenyl-	1*	3,4	U004	D	5000 (2270)
2-Acetylaminofluorene	53963	Acetamide, N-9H-fluoren-2-yl-	1*	3,4	U005	X	1 (0.454)
Acetyl bromide	506967		5000	1		D	5000 (2270)
Acetyl chloride	75365		5000	1,4	U006	D	5000 (2270)
1-Acetyl-2-thiourea	591082	Acetamide, N-(aminothioxomethyl)-	1*	4	P002	C	1000 (454)
Acrolein	107028	2-Propenal	1	1,2,3,4	P003	X	1 (0.454)
Acrylamide	79061	2-Propenamide	1*	3,4	U007	D	5000 (2270)
Acrylic acid	79107	2-Propenoic acid	1*	3,4	U008	D	5000 (2270)
Acrylonitrile	107131	2-Propenenitrile	100	1,2,3,4	U009	B	100 (45.4)
Adipic acid	124049		5000	1		D	5000 (2270)
Aldicarb	116063	Propanal, 2-methyl-2-(methylthio)-,O-[(methylamino)carbonyl]oxime.	1*	4	P070	X	1 (0.454)
Aldrin	309002	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-10-hexachloro-1,4,4a,5,8,8a-hexahydro-, (1alpha, 4alpha,4abeta,5alpha,8alpha,8abeta)-.	1	1,2,4	P004	X	1 (0.454)
Allyl alcohol	107186	2-Propen-1-ol	100	1,4	P005	B	100 (45.4)

Allyl chloride	107051		1000	1,3		C	1000 (454)
Aluminum phosphide	20859738		1*	4	P006	B	100 (45.4)
Aluminum sulfate	10043013		5000	1		D	5000 (2270)
4-Aminobiphenyl	92671		1*	3		X	1 (0.454)
5-(Aminomethyl)-3-isoxazolol	2763964	Muscimol 3(2H)-Isoxazolone, 5-(aminomethyl)-	1*	4	P007	C	1000 (454)
4-Aminopyridine	504245	4-Pyridinamine	1*	4	P008	C	1000 (454)
Amitrole	61825	1H-1,2,4-Triazol-3-amine	1*	4	U011	A	10 (4.54)
Ammonia	7664417		100	1		B	100 (45.4)
Ammonium acetate	631618		5000	1		D	5000 (2270)
Ammonium benzoate	1863634		5000	1		D	5000 (2270)
Ammonium bicarbonate	1066337		5000	1		D	5000 (2270)
Ammonium bichromate	7789095		1000	1		A	10 (4.54)
Ammonium bifluoride	1341497		5000	1		B	100 (45.4)
Ammonium bisulfite	10192300		5000	1		D	5000 (2270)
Ammonium carbamate	1111780		5000	1		D	5000 (2270)
Ammonium carbonate	506876		5000	1		D	5000 (2270)
Ammonium chloride	12125029		5000	1		D	5000 (2270)
Ammonium chromate	7788989		1000	1		A	10 (4.54)
Ammonium citrate, dibasic	3012655		5000	1		D	5000 (2270)
Ammonium fluoborate	13826830		5000	1		D	5000 (2270)
Ammonium fluoride	12125018		5000	1		B	100 (45.4)
Ammonium hydroxide	1336216		1000	1		C	1000 (454)
Ammonium oxalate	6009707 5972736 14258492		5000	1		D	5000 (2270)
Ammonium picrate	131748	Phenol, 2,4,6-trinitro-, ammonium salt	1*	4	P009	A	10 (4.54)
Ammonium silicofluoride	16919190		1000	1		C	1000 (454)
Ammonium sulfamate	7773060		5000	1		D	5000 (2270)
Ammonium sulfide	12135761		5000	1		B	100 (45.4)
Ammonium sulfite	10196040		5000	1		D	5000 (2270)
Ammonium tartrate	14307438 3164292		5000	1		D	5000 (2270)
Ammonium thiocyanate	1762954		5000	1		D	5000 (2270)
Ammonium vanadate	7803556	Vanadic acid, ammonium salt	1*	4	P119	C	1000 (454)
Amyl acetate	628637		1000	1		D	5000 (2270)
iso-Amyl acetate	123922						
sec-Amyl acetate	626380						
tert-Amyl acetate	625161						
Aniline	62533	Benzenamine	1000	1,3,4	U012	D	5000 (2270)
o-Anisidine	90040		1*	3		B	100 (45.4)
Anthracene	120127		1*	2		D	5000 (2270)
Antimony ‡	7440360		1*	2		D	5000 (2270)
ANTIMONY AND COMPOUNDS	N.A.	Antimony Compounds	1*	2,3			**
Antimony Compounds	N.A.	ANTIMONY AND COMPOUNDS	1*	2,3			**
Antimony pentachloride	7647189		1000	1		C	1000 (454)
Antimony potassium tartrate	28300745		1000	1		B	100 (45.4)
Antimony tribromide	7789619		1000	1		C	1000 (454)
Antimony trichloride	10025919		1000	1		C	1000 (454)
Antimony trifluoride	7783564		1000	1		C	1000 (454)
Antimony trioxide	1309644		5000	1		C	1000 (454)

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