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May 8, 2000

Mr. Luis E. Terrassa, Vice-President
Empresas Terrassa, Inc.
24th Street, #35-17, Santa Rosa,
Bayamón, P.R. 00959

Dear Mr. Terrassa,

Enclosed is our report entitled Aggregate Resources In Puerto Rico: A Supply-Demand Perspective. It was written at the offices of Empresas Terrassa, Plant # 3 during the period of March 18, 2000 to May 8, 2000. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Puerto Rico. Copies of this report are distributed simultaneously to Professor Douglas Woods and Professor Laura Menides. Upon faculty review, the original copy of this report will be cataloged in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time and attention that you and all the members of AIPA have devoted to us.

Sincerely,

Kristin Busby

Kevin Delaney

John Rainey

Report Submitted To:

Prof. Douglas Woods

Prof. Laura Menides

Puerto Rico, Project Center

By

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In Cooperation With

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Asociación de Industrias Productoras de Agregados

AGGREGATE RESOURCES IN PUERTO RICO: A SUPPLY-DEMAND PERSECTIVE

May 8, 2000

This project report 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 the Asociación de Industrias Productoras de Agregados 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

This proposal, prepared for the Asociación de Industrias Productoras de Agregados (AIPA) in Puerto Rico, examines the supply and demand for construction aggregates on the island of Puerto Rico. Working from published sources and surveys, we provided AIPA with current and forecasted data regarding the production and demand for aggregates. We also identified and investigated several problems common to producers. This report provides AIPA with data that can be presented to government agencies to support the interests of the industry.

Authorship Page

This statement acknowledges that the project team members contributed equally to the following report. All members of the project team equally carried out each step necessary for the successful completion of the following report. Each member has taken part in reading and writing of the following project.

Acknowledgements

We would like to thank the following people and organizations for their help in the completion of the project.

Advisors: Professor Douglas Woods
Professor Laura Menides
Professor Susan Vernon-Gerstenfeld

Liaison: Luis Terrassa

We would also like to include: Board members of AIPA, all other members of AIPA especially members we interviewed; entire staff of Empresas Terrassa; José R. Caballero from the Planning Board; Pedro Gelabert of the EPA; Juan Castañer of the Planning Board; Angél Rivera of the Planning Board; Sigfrido Torres-González of the USGS; José F. García-Rivera of the DRNA; Carlos M. Guerra-Sierra of the Government Development Bank; Barry Drucker of MMS; Professor Tahar El-Korchi of WPI; Professor Angél Rivera of WPI; Carlos Menxer of the USGS; Christian Pederson from WPI; and the UMET group from WPI.

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EXECUTIVE SUMMARY

The aggregate industry of Puerto Rico is essential to construction and development on the island. Aggregates, including sand, gravel, and crushed stone, are the main components in concrete and asphalt, which are the building blocks of construction. With its rapidly increasing population and construction activity, Puerto Rico has a large demand for these construction aggregates. The objective of this project is to determine the projected demand for aggregates in the future, and to determine the sufficiency of the current supply to meet this future demand.

Prior to this report, there have been no studies analyzing the past growth in the production of aggregates in order to forecast future demand. AIPA, the Asociación de Industrias Productoras de Agregados, has concluded that the aggregate producers, which it represents, would greatly benefit from this type of study. If this study were conducted, it would provide them with vital information from which they could base important business decisions and also to make government agencies aware of the needs of the industry.

Although total aggregate resources on the island are, for all practical purposes, limitless, the availability of these aggregates for exploitation is restricted by many factors such as residential development and the need to protect environmentally important areas. As development continues and residential housing begins moving closer to deposits, aggregate producers experience increased difficulty in the operation of their quarries and encounter more barriers when they try to expand their current operations.

This report provides an estimate of the current production capacity of the aggregate industry and compares this number to a projected figure representing the future demand for aggregates. In addition, this report analyzes the effects of residential development and environmental protection on the aggregate market.

To estimate the current consumption of aggregates on the island, we first obtained cement sales figures from 1971 to 1999. By calculating the approximate amount of concrete this cement could produce per year, we were able to estimate the how much aggregate would be consumed to produce the calculated amount of concrete. Aggregates are also used in asphalt, for which we did not have annual sales. An asphalt producer provided date for recent years and told us that the 1999 figure was the most representative of average asphalt production. Based on asphalt data from 1999, we calculated the percent of the total consumption of aggregate that asphalt production accounted for in this year, and increased each forecasted year's total by this percentage. The result would approximate the total amount of aggregate consumption on the island, and therefore total demand for aggregates on the island.

We analyzed the data on aggregates used in concrete through the use of a regression. As our dependent variable, we used the total consumption of aggregates in concrete from 1971 through 1999. For independent variables, we determined through experimentation that the most influential variables that affect the demand for aggregates are GDP, mortgage rate and a trend variable. Through this regression analysis, we were able to estimate the demand for aggregates through the year 2010.

To estimate the future supply of aggregates, we utilized a list of aggregate producers that included their maximum daily extraction limit. By totaling the maximum

amount of aggregate permitted by day, we were able to estimate the current maximum production capacity. We considered this number as the maximum supply possible.

By comparing the maximum supply of aggregates and the projected demand, we were able to show that, in the year 2010, both of these numbers will nearly be equal and that demand for aggregate is likely to outstrip supply. Therefore, we recommend that the DRNA increase daily extraction limits as well as zone and protect new areas for future quarry operations. These actions would lead to an increase in the supply of aggregates, and help to alleviate this problem. Because aggregates can be economically transported only a short distance, we also compared the maximum supply of aggregates and the projected demand for each of seven regions of Puerto Rico: Aguadilla, Arecibo, Guayama, Humacao, Mayagüez, Ponce and San Juan. We concluded that, in the year 2010, there will be two regions where the demand for aggregates is higher than the maximum supply. In one of these two regions, the demand is significantly higher than the maximum supply.

To analyze how residential development is affecting the supply of aggregates, we interviewed quarry operators who have had problems with local residents, in addition to one who was recently forced to halt production of aggregate due to the complaints of local residents. To reduce the amount of complaints and problems associated with quarry operations, we recommended that producers begin purchasing buffer zones around their quarries. This would increase the distance between the operations and houses in the area, as well as help guarantee that future residential projects will not further approach the quarry. When quarries are shut down, the supply of aggregate decreases. If fewer quarries were shut down, this loss of supply would be minimized.

To study how environmental protection is reducing the supply of aggregate, we interviewed quarry operators. We believe that in many cases, the restrictions and closures imposed on operations due to cave systems and other environmentally important areas are excessive, and often not well planned. We suggest that the DRNA conduct more studies of how blasting and quarry operations affect the environment, specifically cave systems.

This study will be useful to AIPA and its members in that it shows that, in order to meet future demand for aggregates, the DRNA will need to change many current practices as well as to begin to work more closely with producers to remedy prospective problems.

INTRODUCTION

The construction industry of Puerto Rico, like those throughout the world, relies heavily on the aggregate industry for its materials. Since aggregates, such as crushed stone and sand, constitute a major portion of the volume of concrete, they are very important construction materials. Unlike much of the world, the vast majority of Puerto Rico's construction uses concrete as opposed to lumber or steel due to its high strength and resilience. Consequently, Puerto Rico uses more concrete per person than many places throughout the world and is often called the "Concrete Capital."

To manufacture as much concrete as the island of Puerto Rico needs, aggregate-producing companies are constantly looking to expand their operations. However, unlike many industries that can build new facilities quite easily, aggregate companies must first search for available reserves. Consequently, aggregate producing companies buy or lease land that has potential reserves on the property. In establishing a facility, a company must obtain extraction permits from the DRNA and land use permits from the Planning Board. The processes involved in obtaining these permits are often times lengthy, costly, and intricate. Acquiring new permits has recently become difficult due to the close proximity of increasing residential development to potential deposits. It is expected that the amount of aggregate reserves currently permitted for extraction will not be sufficient to meet the future demand for aggregates, and therefore new permits must be issued. To ensure that valuable aggregate deposits are taken into account in the zoning and permitting processes on the island, the government agencies involved must be aware of the significance of the aggregate industry and the need for aggregates.

The aggregate industry is represented by the Asociación de Industrias Productoras de Agregados (AIPA)*. This nonprofit organization consists of the majority of aggregate producers and suppliers in Puerto Rico and serves to protect the rights and interests of the industry. AIPA has commissioned this project to provide information that can be of use to the industry and local governments in defining and improving policy proposals and permitting processes to reflect the needs of the industry as well as the island. By providing quantitative and qualitative data regarding the production of and demand for construction aggregates, AIPA can determine the requirements for new aggregate quarries resulting from economic growth. AIPA can better serve and represent its members by having specific data available to support policy positions and analyze future goals and strategies. In addition, AIPA can provide government agencies with data on the demand for aggregates and the significance of the industry so that policy and permitting decisions will better meet the industry's needs.

To provide AIPA with this information, careful planning and implementation of a specific methodology was utilized. Our methodology consisted of a survey, interviews, a case study and a series of regressions. A spreadsheet survey, distributed to all producing members of AIPA, provided sand, gravel, crushed stone and limestone production data that was compiled into regional totals. A more extensive interview, conducted with several members of the Board of Directors, provided an understanding of the problems, concerns, and obstacles facing the industry. Additionally, we conducted an interview

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* This report was prepared by members of the Worcester Polytechnic Institute Puerto Rico Project Center. The relationship of the Center to AIPA and the relevance of the topic to AIPA are presented in Appendix A.

with a representative of the DRNA and the President of the Planning Board to better understand the processes involved in developing policies and acquiring permits.

One of the major factors affecting the availability of reserves is residential development. In order to study its effect in more depth, we conducted a case study of a series of quarries in the southern region. We utilized interviews to analyze the effect that shutting down the quarries would have on the region. By reviewing transportation costs of aggregates, we were able to approximate the price increase due to increased transportation costs of the area. Also, with projected population numbers for the area obtained from the Planning Board, we were able to show that the demand for aggregates in this area will continue to increase due to increased projected population, and that these quarries are vital to sustain the level of construction growth and to supply the necessary construction materials.

To provide AIPA with future demand projections based on historical data, we ran a series of regressions utilizing several independent variables. The independent variables included several indicators of economic growth, including Gross Domestic Product for Puerto Rico and the mortgage rate. The dependent variable was obtained through the use of cement sales and asphalt sales, which can be correlated to obtain the approximate amount of aggregate utilized in concrete and asphalt, respectively. Based on these regressions we determined the adequacy of the current supply of aggregates to meet the future demand.

While working on this project, we have spoken with the scientists, specialists and professionals that originally made claims about the limited aggregate supply in Puerto Rico. However, we have also spoken with a number of professionals, including

executives of many Puerto Rican aggregate producing companies, who feel that the problem is not that serious. Part of the literature review in this project suggested that the resources on the island may be nearly exhausted, while the reports from the actual producers indicate that the problem is more related to the availability of resources, rather than the existence of these resources. The future of Puerto Rico's economy depends heavily on insuring that supplies of aggregates are adequate and that aggregate resources do not become unavailable due to construction and regulation.

This project is part of the Worcester Polytechnic Institute curriculum called the Interactive Qualifying Project (IQP), and is used to fulfill a degree requirement. The objective of an IQP is to help students better understand how their future jobs affect society as a whole. The IQP accomplishes this by combining both the technological and societal aspects of a problem into one clear and concise report (Worcester Polytechnic Institute, 1999).

This project fulfills the objective of an IQP because it combines the technological and societal aspects of the aggregate industry. The struggle between the technological aggregate industry and the residential development of society is a prime example of the effects that technology and society have on each other. Residential development depends on the aggregate industry for the materials of construction, but residents dislike quarries as neighbors and officials are hesitant to grant the permits necessary to keep the industry in business.

The technology involved in extraction, such as blasting and drilling, cause concern in the community and result in stricter extraction policies. Taking into account society's residential development and also the demand for the aggregate industry, we

have developed projections and recommendations for the estimated need to expand the aggregate industry.

The aggregate industry benefits society by providing jobs and contributing to the stable economy. In addition, the industry provides the material that is essential to one of Puerto Rico's major concerns – residential development. This report provides the data necessary to support policies and decisions that would allow the industry to thrive and continue providing these types of benefits of the industry to society.

LITERATURE REVIEW

Background

According to Johnson (2000), the construction industry of Puerto Rico "spiked" in 1996-1997. This rapid increase in construction caused a significant increase in the demand for aggregates. This increase, along with the already limited production sites, caused a short-term panic on the island. Many producers feared that they would not be able to keep up with the production demand due to the sudden shortage of reserves. Luckily, this period was short-lived, and the construction and aggregate industries both leveled off at acceptable levels.

However, this period was very eye opening for many professionals and producers. This was the first time many people realized that aggregates might be in short supply, while their demand seemed limitless. Consequently, many government agencies attempted to solve the problem by hiring scientists to study the supply of resources on the island.

Most of these studies, although not going into detail, all state the same thing: Puerto Rico is quickly running out of aggregates. Due to these studies, many people felt that Puerto Rico would have to find alternative ways of extracting aggregates from the Earth's crust.

However today, more than three years after the construction and aggregate demand "spike", the majority of the producers see no problem with the supply of resources on the island; they see a problem with reserves. Resources constitute all the aggregates on the island, although they could be uneconomical to extract. Reserves

constitute all the aggregates that currently are economical to extract, or could become economical in the near future. These producers are not worried about running out of aggregates in the near future; although they feel that this may be a reality eventually since urban growth threatens both existing operations and possible future extraction sites by covering unexploited resources and rendering them unusable.

Because of these two contradicting factors, much of the research forecasting problems with the aggregate supply in Puerto Rico is apparently exaggerated. As some suggest, the purpose of these reports was to determine that the island was out of aggregate reserves and then examine economical alternatives that should be used, and this was the reason for these exaggerations.

Aggregates And Definitions

As defined by Glanzman (1993), aggregates are sand, gravel, limestone and crushed stone, or any mixture thereof used for mixing in graduated fragments. They are classified according to grain size. Sand refers to anything ranging from 1/6 to 2.0 millimeters in grain size, whereas gravel is classified as material from 2.0 to 3.5 millimeters in grain size (Werth, 1980: 2). Crushed stone is made from a variety of other minerals. Limestone and dolomite constitute 70 percent of crushed stone, granite 15 percent, and traprock eight percent. The final seven percent of crushed stone is made up of sandstone and quartzite, miscellaneous stone, marble, calcareous marl, slate, shell, and volcanic cinder and scoria (Glanzman, 1993).

In terms of this project, aggregate resources, reserves and deposits are three distinctly different terms. A resource is the entire amount of aggregates on the island.

Resources can be considered generally inexhaustible, unless they are covered up by construction or are otherwise rendered unusable. Resources include all areas of the island that contain aggregates, even if it is uneconomical to extract from these areas. The amount of resources only changes due to the amount extracted from the island, reducing the amount of resources remaining.

Reserves are resources that are currently being exploited, or have been identified for possible exploitation in the near future. Reserves are resources that could economically be extracted. Although at any one time there are a set number of reserves, over time the total as well as the location of these reserves fluctuate. This fluctuation depends on economic changes and exploration.

Deposits are resources that are currently being exploited. The most common type of deposit is a quarry, although others exist. A deposit is a type of reserve. The number of deposits fluctuates over time, although once extraction begins on a deposit, that operation will continue for many years.

Use Of Aggregates

Aggregates are widely used in the construction and paving industries. The primary uses of aggregates are asphalt, concrete and concrete pavements, and Portland cement. Other uses of aggregates include base or sub grade material for highways, railroads, runways, and road surfacing. Sand and gravel are used in utility trenches and storm drains. Sand, gravel, or crushed stone are used in products such as paint, paper, plastics and glass, carpet backing, and insulating fillers of electrical wiring (Glanzman, 1993; Werth, 1980: 5).

Concrete is comprised of three main constituents: water, cement, and aggregate. When cement and water combine, a viscous fluid is created that hardens over time. When aggregates are added to the mix of cement and water, they become suspended in the mixture, held together by the cement and water mix. This final mixture is set into certain shapes, using molds and other means, and hardens into finished concrete over a span of 3 to 14 days (Davis, Kelly, Troxell, 1968: 22).

The exact ratios of these elements differ for different applications of concrete. According to Gani (1997: 50), aggregates on average make up 75 percent of the entire volume of concrete. Puerto Rican concrete producers suggest that one cubic meter of concrete consists of one cubic yard, which means that the ratio of aggregate to concrete is one to 1.307, or 77 percent.

Aggregates are used in concrete to increase strength and resilience, decrease thermal expansion (El-Korchi, 2000) and to increase volume inexpensively (Davis, Kelly, Troxell, 1968: 22). Since aggregates have a higher stability and durability than cement (Gani, 1997: 50), the addition of aggregates increases the strength and decreases the elasticity of concrete. In addition, aggregates have a low thermal expansion that helps reduce the fluctuation of the material when it gets heated up. In other words, unlike some other materials such as metal, concrete does not expand significantly when its overall temperature rises.

Terrassa (2000) has stated that aggregates constitute the majority of the volume of asphalt, and that the ratios of aggregate to asphalt are quite similar to those of aggregate to cement. When roads are made from concrete, they often times crack due to the shifting of the slabs. In a tropical environment like Puerto Rico's, this shifting occurs

more frequently and is more significant. For this reason, asphalt is being used more and more on the island for the production of roadways.

According to Glanzman (1993), aggregates have important environmental uses as well. Material called riprap, large pieces of gravel or crushed stone, is used for soil erosion control around waterways and on slopes adjacent to highways. Aggregates serve as internal drainage in utility trenches and storm drains and as filtration material for water and sewer systems. Utility power plants can also use aggregates to reduce sulfur dioxide toxicants.

Location Of Aggregates

Sand and gravel deposits are, according to Werth (1980:2), numerous in coastal plains and lake deposits, fans of existing and preexisting rivers and streams, and in or near valleys and terraces. Glacial formations also tend to provide such deposits.

In Puerto Rico, the aggregates are scattered throughout the island. The deposits include sand and gravel deposits; limestone deposits as well as crushed stone deposits. According to the USGS (1998), there are a total of twenty-one major deposits of crushed stone in Puerto Rico and twenty-three sand and gravel deposits. Table 2.1 shows the number of these deposits per district. Figure 2.1 shows the various deposits in Puerto Rico that the USGS has accounted for on a map of the island.

It is known that many of the current extracting operations are not included on the map. According to Johnson (1999), the USGS obtains their data from questionnaires that they distribute to each of the aggregate producers on the island. Since these questionnaires are only available in English, many producers simply ignore the

questionnaires, while others report false data. Since the USGS has no means of forcing these companies to respond or report correct numbers, the non-response bias is quite high and the information reported is often incorrect. As Cordero (2000) suggests, many of the smaller producers fear that this information could harm their business, and they can see no benefit to complying with the USGS.

For this reason, USGS information regarding aggregates should be considered a starting point for determining locations of current extraction operations, not a source of complete information.

Table 2.1 – Aggregate Deposits in Puerto Rico by Region

District	Sand & Gravel	Crushed Stone	Total
Aguadilla	3	4	7
Arecibo	5	3	8
Guayama	3	2	5
Humagao	4	3	7
Mayaguez	3	3	6
Ponce	3	2	5
San Juan	2	4	6
Puerto Rico	23	21	44

Source: The Mineral Industry of Puerto Rico and the Administered Islands – 1994

Value Of Aggregates

Aggregate deposits occur according to specific environmental conditions, so there is a limit to the quantity and quality of reserves in a particular area. The value of an aggregate deposit depends on a variety of factors but the most important is the proximity of the deposit to the market place. The material is relatively cost efficient to excavate but quite costly to transport. Hauling 15 tons to a construction site 30 miles away can double the price of aggregate (National Stone Association, 1999). That is, it is less expensive to

extract aggregates from the construction site itself as opposed to hauling it from a different location. For example, the construction of each additional mile of a residential street can cost an additional $15,000 to $20,000 due to the increased transportation costs (National Stone Association, 1999). As a result of such cost situations, most mining industries are located in, or close to, highly developed areas or cities with high demands for construction.

The size and characteristics of aggregate also determine the value. The more gravel a site contains, the more valuable it is. Deposits on coastlines and lake bottoms are of a lesser value due to their high sand content. Werth (1980: 3) has stated that a high content of large materials, such as boulders, is also detrimental to value because the crushing of such material is costly.

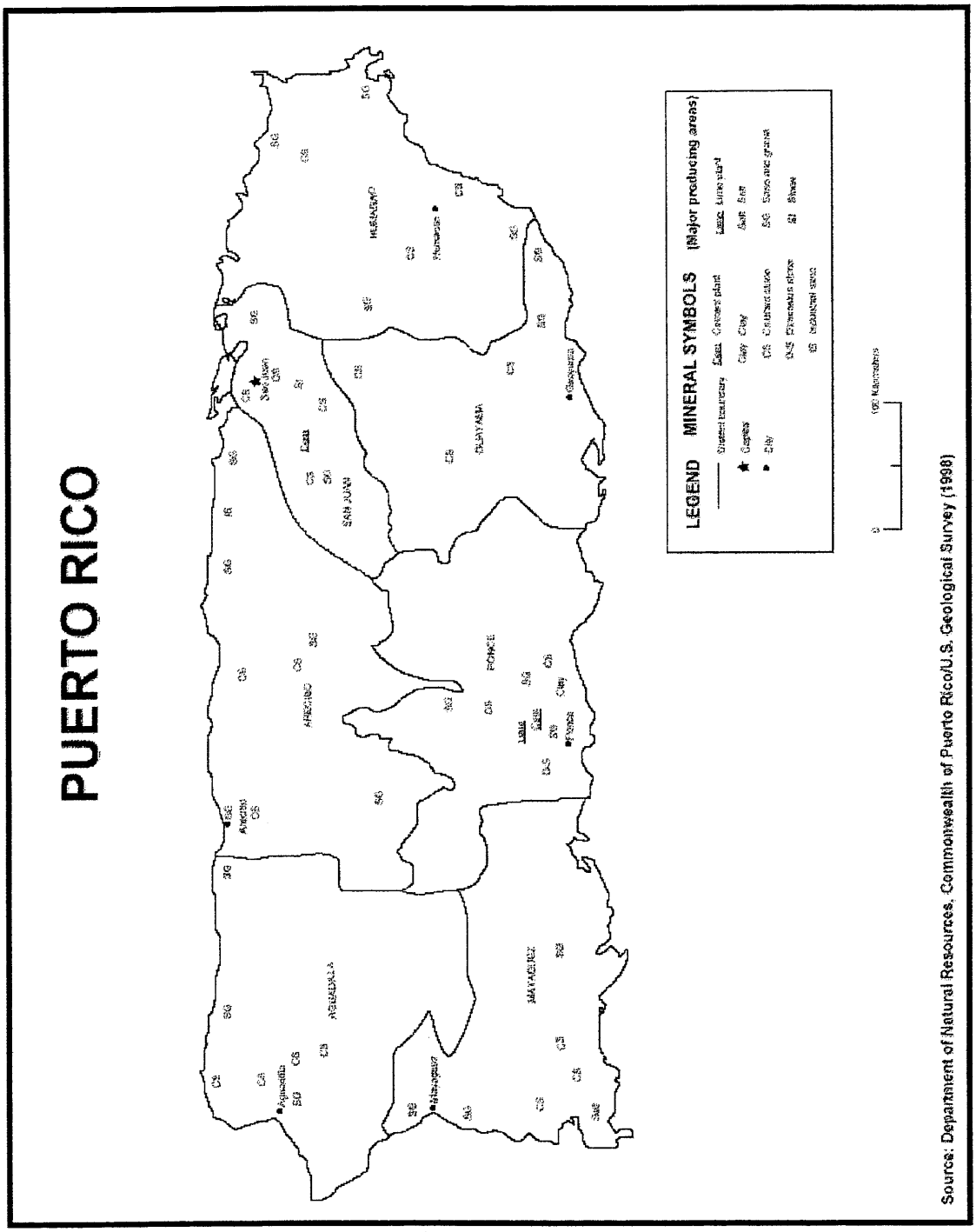
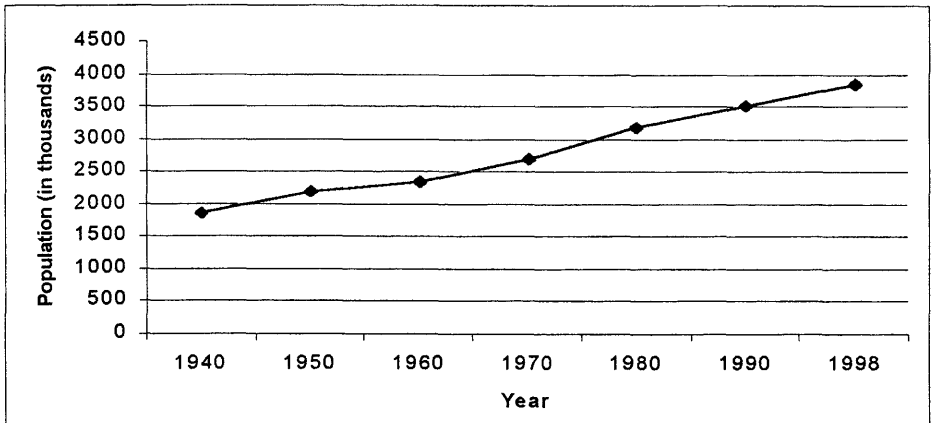


Figure 2.1 – Map showing location of known aggregate deposits in Puerto Rico

Demand For Aggregates

The demand for aggregate resources is related to the growing markets for construction, including housing and roadways. According to Campbell (1999), the construction of roads, buildings, and community infrastructure uses approximately 70 to 85 percent of all crushed-stone material. Construction of a single house can average 120 tons of aggregate, including its use in mortar, shingles, and foundation blocks. Construction of a single mile of a four-lane highway can use as much as 20,000 tons of crushed stone according to Campbell (1999), which is 12,500 cubic meters according to Drucker (1997).

The rapidly increasing population can help to explain Puerto Rico's increasing demand for aggregates. From 1970 to 1990, Puerto Rico's net population grew by over



Source: Rivera-Batiz, Francisco L., & Santiago, Carlos E. (1996). Island Paradox Puerto Rico in the 1990s.

Figure 2.2 - Population Growth in Puerto Rico (1940-1998)

810,000 people (Rivera-Batiz & Santiago: 23). With this population increase came an increase in the need for aggregates, as well as a need for increased land usage. Due to the needs of an increasing population (see Figure 2.2), aggregate reserves are often being covered up by new construction (Terrassa, 1999), while the supply of aggregate is slowly diminishing.

Economic growth on the island can help explain the increase in the demand of aggregates. Puerto Rico has seen an economic boom since the late 1950's since Section 936 (Operation Bootstrap) was passed through Congress. This law made it more affordable for American companies to expand down to Puerto Rico, thus boosting the economy there. This economic boost has led to an increase in construction activity. Since more companies were moving down to Puerto Rico, more buildings had to be constructed, causing an increase in the demand for construction materials, such as aggregates. In addition, with these companies' new presence on the island, many more jobs were created. This led to an increase in the average annual income, which also led to increase construction.

According to Cordero, it is every Puerto Ricans dream to return to the island successful, and continue to work close to their relatives and where they grew up. Because of this philosophy, many Puerto Ricans living in the United States migrated back to Puerto Rico. Once there, they built new houses for their families, which increased both population and construction.

In 1997, Puerto Rico's Department of Natural and Environmental Resources (DRNA) requested a full study of Puerto Rico's current aggregate supply status and a study of alternative ways to extract aggregates from Puerto Rico. Barry Drucker and

Roger Amato from Minerals Management Service (MMS) provided DNER with information relating to aggregate depletion on the island, as well as a projection of future aggregate supplies. Their results were surprising to those in the Puerto Rican aggregate industry; they estimated that Puerto Rico would run out of land-based sand deposits in the year 2000 (MMS, 1997).

Legal Restrictions For Mining

In the development and maintenance of mining sites certain codes, laws, and legislation are followed in Puerto Rico as on the United States mainland.

The Planning Board, the Environmental Equality Board, and DNER regulate land use in Puerto Rico. The Laws of Puerto Rico Annotated (LPRA) state that development policies must adhere to those of the Mining Act (Section 110) and the standards, rules, and regulations adopted by the Secretary of Natural Resources. In 1996, a Committee for Negotiations of Mining Affairs was created within the DNER. The Committee of seven members, representing the Planning Board, the Department of Justice, Health, Treasury, Agriculture, Transportation and Public Works, and a private citizen, serves as an advisory board to the Secretary of Natural Resources.

Planning Board

As expressed in their official web site (1999), the Planning Board is a part of the Governor's Office and consists of three members and an alternate member appointed by the Governor with the advice of the Senate of Puerto Rico. The Governor also designates a President. The President of the Planning Board designates a Vice President and

administrators. The Planning Board is responsible for developing an investment program, preparing and adopting plans for the use of resources, and providing for the socioeconomic development of the entire population of Puerto Rico. The Planning Board consists primarily of three offices: the Social and Economic Planning Board, the Program for Physical Planning, and the Program of Information Systems. The Social and Economic Board and the Program for Physical Planning have policies, which apply to natural resources and construction (Junta de Planificación, 1999).

The Social and Economic Board is responsible for collecting data on the economical and social aspects of the island. The information acquired is used to make decisions of public policy. The data collected includes estimates of the gross product, consumers' personal spending, personal income, consumer debt, the value of construction activity, and the value of exports and imports. The Board provides a Construction Indicator that estimates public and private investments in construction. An Indicator of Construction Permits is also provided. The indicator uses the monthly reports of the Administration of Resources and Permits and reports from individual municipalities as a basis for the number of distributed permits. The information the Board collects is reported in the Annual Report to the Governor (Junta de Planificación, 1999).

The Program for Physical Planning is responsible for the process of territorial and urban planning. The Program establishes public policy for the use and design of the land and assesses and evaluates territorial ordinance plans for the municipalities. The Program has several subprograms, such as the Zoning Unit, and the Urban Expansion Unit. The Zoning Unit evaluates possible changes in previous zoning for land use. The

Urban Expansion Unit prepares maps and evaluates petitions for the designation of natural reserves and historical sites (Junta de Planificación, 1999).

The main objective of the Planning Board and its subprograms is to develop plans and public policies for the use of land so as to benefit the economic development of the island (Junta de Planificación, 1999).

Public Policy

According to LPRA (Title 28, Part I, Chapter 7 of LPRA), the policy of the Government of Puerto Rico is to use their mineral resources to best benefit the Puerto Rican people of the present and the future. Exploitation of materials must consider the conservation of other resources and the protection of the environment. Developers are encouraged to use the most advanced techniques in extraction in order to prevent environmental hazards. Open pit mining, strip mining techniques, and any other technique that significantly alters the natural land used for extracting nonmetallic resources, is prohibited by law. Quarries are not considered open pit mines, according to the Bylaws of Extraction produced by the DRNA (Appendix E); quarries must operate by the banks and terraces method.

This method is the best way to remove aggregates from a mountain. The quarry begins atop a mountain and slowly removes material, working from top to bottom lowering the land. At any given time, there can be numerous levels of operations, where the bottom of one level is the top of another. This process continues until the land is even to the land surrounding the quarry, and may never reach water table level.

Land Use Plans

Puerto Rico development policies, decided by the Planning Board with approval of the Governor, must follow Land-Use Plans (LPRA, Title 23, Part I, Chapter 1a). Land-Use Plans are intended to set criteria for determining the priorities in issuing land permits and zoning ordinances. These plans cover rural, urban, agricultural, mining or forestry purposes, and consider conservation and protection of natural resources, recreation, transportation and communications, power generation, and residential, commercial, industrial, educational, public and institutional activities.

The Board is required to prepare a land budget consisting of the quality and location of the demand for land. It is the Board's job to promote preparation of inventories of the land and natural resources, price and quality of land, and surveys on the nature and compatibility of the land to meet future demands. (LPRA, Title 23, Part I, Chapter 1a)

Permits For Mining

The LPRA (Title 28, Part I, Chapter 7) defines two types of permits that are issued for the leasing of land for mining operations: exclusive prospecting permits and nonexclusive permits.

Exclusive prospecting permits restrict the use of the land to one specific mineral or to closely related minerals. The perspective mining site is restricted depending upon the type of mineral, its value, and its estimated cost of extraction.

Nonexclusive permits do not have specific restrictions and do not include advance lease rights. Both types of permits are issued on a year-to-year basis and require

submitted reports following use that include maps, measurements, value of production, and an assessment of the environmental impact on the land.

Societal Impacts Of Mining

Society relies on construction of both housing and roads for economic expansion. If the aggregate supply were to run out in Puerto Rico, the construction companies would need to acquire the necessary aggregates from other locations off the island. As a result, common sense suggests that housing costs and the overall cost of living would increase. With this in mind, the impacts of future mining on Puerto Rico's society, whether environmental or economical, will be important.

Environmental Impacts

Aggregate extraction, according to Werth (1980: 13), can cause problems related to water, soil, and air. Materials that settle after extraction can clog water sources. Siltration and turbidity problems in the water can also occur as a result of extraction. Surface water pollution, however, is not always a concern because water moves into, not out of, a quarry. Although according to Cordero (2000), during the rainy season it is difficult to control water pollution. When rainwater mixes with process water, it becomes the company's duty to keep all the water from flowing off the grounds and into rivers, streams and lakes, therefore helping to decrease damage to the environment. For this reason, many aggregate-producing companies have designed intricate water controlling systems to help control water runoff.

Air pollution is also a factor to consider. Although sand and gravel processes do not produce as much pollution as other types of surface mining, they produce enough dust to cause complaints from neighbors and also cause respiratory problems.

According to Werth (1980: 13), erosion damage is the largest environmental concern. For example, strip mining strips the topsoil off the site, and can result in erosion.

Johnson (2000) has stated that quarries have positive effects on the environment. For example, in Puerto Rico the soil does not contain a large amount of minerals. For this reason, plants and trees often have difficulty growing. However, due to sand particles in the air, the soil that surrounds a quarry is better mineralized than soil not near the quarry. This could be beneficial to farmers, who could take the soil and put it on their fields.

Economic Impacts

The mining industry of Puerto Rico is an essential part of Puerto Rico's economy. A large part of Puerto Rico's economy is tourism (Rodriguez, 1996). In order for tourism to thrive on the island, hotels and tourist attractions are constantly constructed or upgraded. These types of buildings, often made of concrete, have a major role in the total construction on the island. Because of this contribution, Puerto Rico's economy would suffer if all mineable aggregate resources were exhausted.

Alternative Methods Of Mining

Whether or not the aggregate deposits on Puerto Rico are currently approaching depletion, the fact remains that they are limited and economic sources may someday be exhausted. Whether, as Drucker's report suggests, this occurs in the near future, or as many in the industry predict it does not occur for years to come, the fact remains that someday shortages are likely.

With this in mind, alternative methods of extraction may become increasingly important in the future. Moreover, alternative locations of aggregate deposits could be vital to Puerto Rico's economic future.

Riverbed Extraction

According to the USGS (1995), extracting sand from riverbeds has caused large problems in the past. Not only has it permanently damaged Puerto Rico's delicate ecology, but has also caused problems in public water supply. This problem occurs because extraction of sand from rivers and reservoirs has increased the amount of erosion in these areas. Due to this erosion, by 1995 some reservoirs were filled with sand as opposed to drinking water. At the same time, an increased demand for water due to the rapidly growing population led to the need to ration drinking water. With half the water-holding capacity of reservoirs disappearing due to sediment build up over the last fifty years; over two million people were affected between 1994 and 1995 (USGS, 1995).

Beach extraction

Extracting sand from beaches is a simple and inexpensive process. As of 1996, over 85 percent of Puerto Rico's entire population lived within five miles of the ocean.

Therefore, a considerable amount of construction has occurred in this area (Rodriguez 1996). As earlier stated, the cost to transport aggregates is quite high, and therefore it was cost effective and convenient to remove sand from beaches close to construction sites.

Erosion became a major problem in coastal communities in Puerto Rico due to extraction of beach sand. Problems included flooding of coastal communities as well as increased damage from Atlantic storms also caused by the extraction of sand from beaches (USGS, 1995).

Although not the case in the past, laws now restrict the extraction of sand from the beaches of Puerto Rico. However, similar to the laws prohibiting riverbed sand extraction, the laws governing beach sand extraction were implemented too late.

After the laws were put into effect, albeit illegal, sand was still taken from Puerto Rican beaches and is a continued cause of increased beach erosion (Rodriguez, 1996). This is true for two reasons. One reason is the natural abundance of the sand. The other is that the sand is valuable due to its location relative to construction.

Recycled Concrete

Recycled concrete is a newly discovered form of concrete production. Approximately 40 percent of landfill waste comes from the demolition and construction industries, a large portion of which is concrete (Environmental News Network, 1999). The countries of Australia and the United States have utilized recycled concrete successfully in road construction (Komorita, 1998). If used, recycled concrete could help reduce the need for new aggregates in parts of the construction industry.

Industry specialists in Puerto Rico warn that recycled concrete has too many problems with strength, type and reliability, and therefore will never become a serious substitute for earth-crust extraction.

Importing & Exporting Aggregate Resources

The option exists for Puerto Rico to import aggregate resources to the island from other countries. Importing resources is quite expensive due to transportation costs, but is a possibility if all onshore aggregate resources are exhausted. However, government regulation makes it nearly impossible to import aggregates to the island. One producer on the island stated that by definition, aggregates are materials cheaper to take out of the ground than to export. For these reasons, importing aggregates could be difficult to accomplish.

In 1997, according to Drucker (1997), Puerto Rico exported approximately 900,000 cubic meters of sand and gravel to the Virgin Islands, although industry specialists dispute this number. If it were true, cutting down on the exportation of aggregates would increase supply on the island of Puerto Rico.

Offshore Mining

Offshore mining, commonly called dredging, could become a viable alternative to onshore mining. From reviewing sources (Drucker, 1997), it is believed that since Puerto Rico is a small island, finding new, previously undiscovered resources is unlikely. In addition, although the short-term benefits of some of the previously mentioned methods are advantageous, the problems relating to the long-term effects offset the short-term benefits. The short-term benefits include increased sand resources while the long-term

problems include erosion due to sand extraction from beaches. Although this offshore dredging solves the short-term sand and gravel shortage problem, it can cause much larger environmental problems over time (Drucker, 1997).

Offshore mining can cause similar effects to the environment of Puerto Rico as riverbed and beach sand extraction did. According to Drucker (1997), because not many offshore dredging operations existed in Puerto Rico, the full extent of the adverse effects due to offshore mining was not entirely known. USGS studies suggest that there are three major offshore sand and gravel deposits that are possibilities for future excavation sites (Drucker, 1997).

According to Drucker (1997), Escollo de Arenas, the largest of the major deposits, is located less than 5 miles off the northwestern tip of the island of Vieques. This deposit consists of both sand and gravel and has between 30 and 90 million cubic meters of mineable aggregates.

Drucker (1997) states that there are serious environmental impacts relating to the offshore sand extraction from the Escollo de Arenas site. One impact is an increase in wave strength and size on the northwestern coast of Vieques. The Escollo de Arenas deposit acts as a barrier that obstructs the waves heading for the island of Vieques. Without this barrier in the future, there is the possibility that a storm or natural disaster could seriously affect the island of Vieques. The impact of the excess waves on Vieques due to the loss of the barrier is not definite due to the short amount of time that the offshore facilities have been in use.

Another environmental impact of the sand excavation from Escollo de Arenas is the destruction of sea grass, says Drucker (1997). The actual mineable volume of

aggregates obtainable from this site is not a technological question at this point; it is an environmental question. Since over 60 million of the 90 million cubic meters of sand and gravel is covered by sea grass, environmentalists fear that the extraction of over 30 million cubic meters can cause substantial decrease in the sea turtle population that currently depend on the grass for a source of food (Drucker, 1997). Also, the reshaping of the seabed, due to extraction, could cause long-term changes in the animal population in the area as well as causing a disruption in the spawning grounds for fish, Drucker (1997) suggests.

Researchers worry that removing sands from the seabed would cause further erosion on the beaches (Drucker, 1997). Due to large ocean storms eroding beach and sand deposits off the coast, offshore extraction could cause further unwanted erosion on the coast. Waves generated by hurricanes, for example, have moved sand in Escollo de Arenas away from the island to the northwest. As a result, there is a concern that beach sand will erode and take the place of extracted sand in the offshore deposit (Drucker, 1997).

The second deposit, Cabo Rojo is located off the southwestern coast of Puerto Rico. Similar to Escollo de Arenas, the precise volume total of mineable sand is not known. Studies have indicated that only 10 million of the 80 million cubic meters of sand are not covered by sea grass (Drucker, 1997), and therefore the other 70 million cubic meters of sand might cause environmental problems if extracted.

As stated by Drucker (1997), environmental concerns related to extraction from this area include changes to fishing populations and removal of sea grass and coral reefs

in the area. Also, increased erosion that would lead to a decrease in beach sand is a fear of inhabitants along the shore.

The third large deposit, called Isabela, is off the northwestern edge of the coast of Puerto Rico. As indicated by Drucker (1997), this deposit is estimated to contain only 8 or 9 million cubic meters of sand and gravel. Due to its steep slope and large waves, this site is the most difficult of the three offshore deposits to exploit. Even though Isabela's location makes it a difficult site to excavate, extraction of minerals from the Isabela deposit would have little to no environmental impacts on the surrounding area. Because of the lack of environmental impacts due to its location, Isabela is currently being exploited (Drucker, 1997).

Since entirely new machinery is required for offshore dredging, the startup costs for this type of activity are expensive. Costs include the cost of operation, permit fees, transportation fees, as well as processing fees (Drucker, 1997).

According to Drucker's report, average dredging costs off the eastern coast of the United States in 1997 ranged from $6 to $11 per cubic meter. The average cost of aggregates in San Juan was between $25 and $40 per cubic meter and elsewhere on the island it cost $15 to $25 per cubic meter. Sand from the Isabela deposit cost approximately $13 per cubic meter[1], which was significantly less expensive that the average cost of materials that were excavated on the island (Drucker, 1997).

This lower price occurred because of the difference between land and water transportation prices in Puerto Rico. In 1997, the average cost of trucking 1 ton of sand or gravel per mile was between $.10 and $.15, whereas it cost only $.03 per mile to

[1] Converted from tons to cubic meters by students.

transport the very same materials by water (Drucker). This was because the trucks that transported the aggregates could only hold 9 to 12 cubic meters of material, whereas a boat that transported the aggregates could hold much more. Therefore, it was more economical to exploit a site on water that was three times farther away from the construction site than a similar site on land.

Since Escollo de Arenas is approximately 60 miles from San Juan, it was less expensive to transport aggregates from there to San Juan than to transport from a land deposit 20 miles away. Likewise, Cabo Rojo is 140 miles away and Isabela is 80 miles away from San Juan.

Research Methods

Research methods offer alternative ways of obtaining information that is not readily available from books or other published materials. In some cases, it is necessary to resort to these alternative methods in order to successfully complete a task. Two of these alternative research methods are regression analysis and survey research.

Regression Analysis

Woods (1998) states that a regression analysis determines the "quantitative functional relationships" that exist between a number of variables. For this project, two or more variables are used in each linear regression, one or more independent variables and one dependent variable. The independent variable(s) in the regression equation affect(s) the dependent variable. A dependent variable changes with respect to the

changing independent variable(s). The dependent variable has no effect on any of the other variables in the regression (Vernon-Gerstenfeld).

For this project a least squares regression is the best choice. A least squares regression projects the line of best fit onto the entire set of data points. This line minimizes the sum of the squared errors (SSE). The definition of error in this case is the distance from the line to each individual data point. It is necessary to square the error and produce a positive result so that the summation of all the errors will not cancel out negative errors or data points below the line of fit. After finding the line of best fit, a calculation of the equation of the line is essential so that future values are determinable (Schroeder & Sjoquist & Stephan, 1986: 19-21).

Survey Research

When historical sources do not provide sufficient information on a topic, survey research sometimes helps to alleviate this problem. However, one problem with survey research is that it is dependent upon the truthfulness of the people surveyed.

The purpose of a survey with respect to this project is to obtain recent quantitative information. Much of this information is not yet available from other sources; therefore, it is necessary to obtain this information from unpublished sources. In many survey situations, confidentiality is an important aspect when company specific information is in question.

Another purpose of the survey is to validate much of the data obtained from other sources. For example, much of the information available relating to the future availability of aggregate resources on the island suggests that Puerto Rico will run out

soon. Industry specialists on the island say that statement is not true. Surveys could be used to validate this type of data in an attempt to get the best information available.

METHODOLOGY

The methodology for this project consisted of four phases: a regression analysis, a survey, interviews, and a case study. The regression analysis, based on historical data, allowed us to project future demand of aggregates depending on the level of economic growth. The survey provided aggregate production totals compiled by region from which we were able to determine the current production of aggregates. In addition, interviews presented a sense of the problems and concerns of the industry. Finally, a case study analyzed how residential development affects the aggregate market.

Regression Analysis

Our multiple variable regressions correlated a variety of economic variables with cement and asphalt production. The economic variables were the independent variables and aggregate consumption was the dependent variable. Based on the future value of the economic variable, the demand for aggregates was projected from this regression.

Independent Variables

The independent variables of the regression included mortgage rates, gross domestic product (GDP) and a trend variable. The data was collected for the fiscal years 1971 to 1999 and projected for the years 2000-2010. The Planning Board of Puerto Rico projected future GDP values, and mortgage rate is projected to be eight percent, through the advise of a financial analyst.

Mortgage rates were chosen as independent variables because they drive rates of construction activity. When mortgage rates decrease, people begin investing in buildings and houses. According to Juan Castañer of the Planning Board, the people of Puerto Rico generally do not place much emphasis on loan interest rates when making an investment decision. Potential investors instead consider mortgage rates. Therefore, mortgage rates are a stronger variable driving construction activity. Bank prime loan rates have a greater effect on the contractors of construction, therefore having some influence on construction activity, but not nearly as much as mortgage rates.

Gross domestic product reflects the rate of economic growth. At stable or increasing growth rates, investment and construction activity will continue to increase. As the economy grows, income levels rise and spending increases, which results in increased tax revenue for the government. For this reason, both individuals and government agencies have more money to spend on construction, whether it is a modest addition to a house or a large government investment such as the urban train or the superaqueducto.

These variables will be most useful to the industry in the future because the data is readily accessible, so therefore, a demand forecast based on these variables will be simple and reliable.

Dependent Variables

We ran a series of multiple variable regression analyses with one dependent variable and three independent variables. The dependent variable was aggregate consumption. This variable was obtained by estimating the amount of concrete that can

be produced by a given amount of cement bags sold. The data for cement was recorded in bags produced or sold, where each bag is equal to 94 pounds.

This amount of concrete produced was then used to estimate how much aggregate is in the concrete. We used cement sales statistics rather than aggregate production because aggregate production data is difficult to obtain and is neither complete nor accurate.

We then completed the regression analysis and obtained an equation that relates aggregate consumption to GDP, mortgage rates and a trend variable. This way, given the GDP, mortgage rate and trend values, we are able to determine the approximate amount of aggregate that will be consumed for concrete production during that year.

To include asphalt production, we obtained 1999 asphalt sales figures. An asphalt producer told us that this 1999 value is representative of the average yearly asphalt production. Since no other exact sales numbers are available, we determined the percent of the total consumption of aggregate that asphalt production accounts for using the 1999 value, and decided to increase each year's total by this percentage. We increased the numbers obtained through the regression analysis by this percentage, 19.3 percent, and this yielded the total aggregate demand.

Survey

A survey was distributed by fax and in person to all twenty-nine producing members of AIPA. The survey, in the form of a spreadsheet, requested production totals in cubic meters for the years 1995-1999, for each site of extraction. Additionally, we asked members for the region and address of each site's location, the type of material

they extract, and the approximate size of the reserve. We only surveyed the members of AIPA, rather than the entire industry, because AIPA members were aware of the project and were expected to be more cooperative than independent companies. Even with this fact, however, we expected that not all of the members of AIPA would return the completed survey.

Estimation of Production

Taking into account the non-response bias and the non-associated members of the industry, we devised a method to closely estimate production. We obtained lists of all current production facilities from the DRNA and MSHA. The DRNA list included the maximum amount of daily extraction that the company applied for at the time the permit was issued or renewed. From this size data, we were able to group the facilities by relative size by comparing the maximum amount of daily extraction from the DRNA permits. We chose two facilities from each group and obtained and verified their production totals by sending them our production spreadsheet and obtaining production numbers. By surveying just two facilities, we were able to obtain relatively accurate numbers and reduce the non-response bias. We then estimated that each of the facilities in a size group would produce the amount provided by the sample companies. This was done for each size group, and then the production numbers were added together to obtain an estimate of the total aggregate production on the island.

Regional Production Totals

Production data was also totaled by region, to get a sense of the areas with the greatest amount of production and needing the most attention in the permitting and policy processes. We divided the island into seven regions: Aguadilla, Arecibo, Guayama, Humacao, Mayagüez, Ponce and San Juan. We chose this division because each region contains one of the seven major cities on the island. The regions of facility locations were reported by the companies on our survey, and were available from MSHA and the DRNA, so this information was not difficult to obtain.

Regional Demand for Aggregates

We forecasted the demand for aggregates by region in order to determine the areas needing the most protection from permitting agencies to protect the aggregate resources. We used regional population data projections from the Planning Board to find which areas of the island are projected to have the greatest amount of residential growth, which would affect the availability of aggregate reserves. In addition, the areas of greatest projected future residential growth will have a large demand for aggregates due to the high construction activity.

To obtain quantitative data for the regional demand for aggregates, we obtained the forecasted population per municipality on the island. We separated each municipality into its respective region. We then totaled the current and forecasted populations from the Planning Board for each region in increments of five years, from the year 1990 to the year 2010. We then found the percent change in population per municipality in comparison to percent change in total population of the island during the same amount of

time. This demonstrated what percent of the total change in population each region of the island represents. With this information, we were able to determine which region of the island will experience the greatest increase in population.

This number will also allow us to estimate the total demand for aggregates per region. Using the total demand in Puerto Rico for aggregates per year, which we obtained using the regression analysis, and multiplying that number by the percent of total population change per region, we were able to break down the demand of aggregates by region.

Interviews

Interviews were conducted with the Board of Directors of AIPA and several government agencies. By conducting interviews, we hoped to learn about government policies and permit application processes as well as the significance of the aggregate industry in the economy and the concerns of aggregate producers.

Board Members

Interviews were conducted with the majority of the members of the Board of Directors of AIPA. The questions asked for their opinions on issues such as the permitting process, public relations, environmental regulations and concerns, and problems with residential development. The interviews yielded an idea of the problems that concern the members of the industry, as well as what types of action they plan to take to alleviate these problems. The interviews were intended to provide the industry's perspective on issues common to the industry. The interviews were kept confidential by

compiling the answers together in no specific order, and without reference to the interviewee. The questions as well as the anonymous responses are available in Appendix B.

DRNA

An interview with the Department of Natural and Environmental Resources (DRNA) was held to help us better understand the permitting process. We focused on two different types of permits: construction permits and extraction permits. Since these two types of permits are what many aggregate producers view as a major source of problems within the industry, we spoke in depth with DRNA officials regarding this matter.

The types of questions asked ranged from basic questions about the permitting process to in depth questions pertaining to the types of outside factors, such as the relative location of residential projects to the quarry, that affect the permitting process.

Questions were also directed toward the criteria the DRNA uses to decide whether to grant a permit as well as other matters that the Board of Directors of AIPA saw as problems; such as why the DRNA issues extraction permits for a short period of time, and not for the life of the quarry.

Planning Board

The interview with the planning board was conducted to obtain information about zoning laws and practices as well as processing permits.

Most importantly, we questioned members of the planning board as to whether the proximity of unused aggregate resources is considered when issuing a residential

permit. Questions pertaining to the above topic ranged from asking about what types of outside factors influence the zoning practices to what type of planning is done to preserve aggregate reserves.

The other type of questions, relating to processing permits, were also directed toward better understanding the permitting processes. The questions were used to help us better understand what type of factors the Board looks at when issuing a processing permit, and why it seems that these types of permits are given out less often than extraction permits.

Case Study

We conducted a case study of the southern region's aggregate market. In particular, we analyzed one specific area of the island that has four separate quarry operations in a small area. These quarries supply the majority of aggregates in the Ponce region as well as throughout the southern half of the island, and therefore are very important to the construction industry. We analyzed the significance of this market within the local community and surrounding regions. Specifically, we studied the effects the quarries have on construction and aggregate prices, employment, and the quality of life in the area.

We also created a map of Puerto Rico that contains all the DNRA permitted extraction sites. We did not include operations that we were told were not currently operating. This map was provided to AIPA for their benefit.

DATA, RESULTS AND ANALYSIS

In this chapter, we discuss all the data that we acquired through the methods discussed in our methodology. The data that we obtained through interviews as well as from our spreadsheet survey is discussed in detail. The regression equation information is reported in this section as well as an explanation of the raw data results. With this regression information, we forecasted the demand for aggregates for the entire island and for each separate municipality. Finally, this chapter will include our analysis of one example of the problems resulting from residential development.

Interviews

We interviewed members of AIPA to learn their opinions about the aggregate industry, the DRNA and the permitting process, and problems with residential development. We also interviewed the DRNA to understand the permitting process and to compare the opinions about the aggregate industry from the DRNA perspective with that of the members of AIPA.

Board of Directors of AIPA

We interviewed six members of the Board of Directors; the other members of the Board of Directors were unavailable for comment. Following is an analysis of the discussions.

We began by asking basic questions about their companies. We asked when each company was established in order to demonstrate that the companies interviewed have a

long and reputable history in the aggregate industry. The opinions of their owners have much knowledge and experience behind them, because each operation has been in business for twenty-five to fifty years. Five of the six companies have expanded their operations by at least one hundred percent in the past twenty years. Each company began with only one plant and now they currently account for seventeen plants collectively. A few of the company owners expressed that they have not expanded much in the past ten years. At least one member stated that they were trying to acquire new permits to expand their production but have been unsuccessful with the DRNA.

Everyone who is actively searching for new extraction locations and permits is having difficulty because, as a member of the Board stated, "available/permittable sites are becoming quite scarce." We discussed this issue in depth with the Board Members and learned that the major obstacles in acquiring new permits are the increasing residential development and the problems with the permitting process of the DRNA.

Each Board member that we interviewed has residential development close to their operations. Although a few of the members do not have any major problems with nearby residents, each is aware of the likelihood of residential development becoming an increasing problem as it move closer to the quarries. At all but one plant, the production facility was established prior to the developing communities. Several members explained that although the quarry existed first, the complaints and problems with residential development threaten the future operations at these quarries as they attempt to utilize their current reserves.

The other obstacle the companies face in expanding their operations is the permitting process. In the opinions of Board members, the problems include the length

of the process, the duration of the permit, and the DRNA's lack of personnel, budget and training with respect to the aggregate industry. Only one person commented in our interviews about the problem with the length of the permitting process. However, others have expressed the same opinion in other forums.

The majority of Board members expressed a concern with the duration of the permit. Five of the six interviewees felt that the DRNA should consider issuing permits for longer than three years while the sixth member never brought this up as an issue. They all agreed that since the DRNA has the ability to intervene at any time when the company is not complying with regulations, there is no need to renew permits every three years. Most of the Board members believe the permit should last for the life of the quarry, due to the large investment requirements within the industry. They also agree it is inefficient to cease the exploitation of a quarry before its reserves have been exhausted.

In addition to the previously mentioned problems with the DRNA's permitting process, many of the Board members expressed an opinion that the DRNA is understaffed. These members feel that the DRNA does not have enough employees to effectively evaluate quarry operations and determine whether current regulations are effective or whether they need to be changed. In addition, many Board members feel that the permitting process is lengthy because there are not enough DRNA employees to review and reissue the permits.

Another concern of the Board members is that the general population does not distinguish between a bona fide aggregate producer and a construction operation. Many construction contractors use aggregates as fill to level the land in which they intend to build. This type of operation requires a DRNA permit but not a processing permit from

the Planning Board. In addition, these contractors are not obligated to follow the same type of strict regulations that bona fide producers must follow. As a result, all of the Board members that we interviewed expressed concern about how the production industry is being held responsible, in the public's eye, for all environmental damage done by these contractors. In addition, many Board members feel that the closeness with which these contractors extract to residential housing is causing increased complaints near bona fide quarry operations.

These concerns have led a few of the Board members to take part in public relations projects. Three of the Board members felt that public relations are a problem that the entire industry faces. In addition, these three members were concerned regarding illegal extraction from unpermitted areas. They feel that the public does not, as in the case with contractors, recognize the difference between these types of operations. According to one Board member, these operations usually take place close to or on major roads and cause serious environmental damage. As a result, many residents of the area see this damage and believe that quarries cause the same type of environmental damage.

When asked how the aggregate industry benefits the local community, the four producers that were asked this question all responded with the same answer. First, the industry provides jobs for the local community. Second, it provides aggregates or concrete to nearby towns to help build schools, churches and roads. Most importantly, the Board members feel that they help the economy grow. According to one member, growth depends on concrete, which depends on aggregates. Without construction growth, the economy goes nowhere. Another member reminded us that aggregates are

used as fertilizer (limestone), and another member told us that they are also used as an additive in hamburgers and filler in toothpaste.

When asked whether the larger operations should be given permits ahead of smaller operations, many observed that size is not as important as experience. Although most members agree that larger operations are generally more efficient than smaller ones, discrimination based solely on size in unfair. Two members explained that although it can be expensive to operate a small company, this type of company has the right to extract as long as they are following the laws and regulations. However, one member feared that if the DRNA gives out permits to smaller operations, residential developments might move into areas around the operation that could have been used as part of the quarry. His opinion is that the larger producers are able to purchase larger plots of land, which will cover the entire reserve, whereas smaller operations are only able to purchase a small plot that contains only a portion of the reserve. If this situation were to happen, according to this member, then residential developments will move into the area, covering the reserves and effectively rendering them unusable.

A question was asked that deals with what the land will be used for once the quarry's reserves are fully exhausted. Four of the six Board members said that once the quarry operations are finished, that they plan to zone the land for industrial. One member stated that he would wait and see what type of zoning demand there is in the future, whereas another Board member stated that that is a decision left up to the company's Board of Directors.

The final question asked dealt with reclamation of the land, or reforestation and adding vegetation to the area. Five of the six members interviewed stated that they have

some sort of planting program in effect, varying in size and cost. One member explained how they were forced to pay a certain amount toward reclamation each year the quarry was in operation, even though reclamation could only occur during the final stages of a quarry's life.

Asphalt Producer

We interviewed an asphalt producer to acquire knowledge of the asphalt industry and how it relates to the aggregate industry. He provided some background information on asphalt as well as an estimation of asphalt production on the island for 1999.

We learned that aggregate is the main ingredient in asphalt. Asphalt is sold as surface material or base material, each containing different sizes and amounts of stone. As a general rule of thumb, though, asphalt is comprised of ninety-five percent of different sized stone and sand, and five percent liquid asphalt cement. The asphalt companies use locally produced aggregate and imported liquid asphalt cement. In an average year, fifteen percent of the asphalt produced on the island is used for projects such as primer or roofing, while the rest is used for paving roads and highways.

This asphalt producer provided us with some conversion factors.

1 ton of asphalt = 3200 cm^3 of asphalt
1 ton of asphalt = 0.6 m^3 of asphalt
1 m^3 of asphalt = 1.667 tons of asphalt
1 ton asphalt = (1/1.667) * 0.95 m^3 stone and sand
(The previous conversion is a combination of the amount of cubic meters in a ton and the percentage of aggregate (stone and sand) in asphalt.)

The total production of asphalt for the island is unavailable from the Department of Transportation, the Highway Authority, and the Department of Economic Development and Commerce. This asphalt producer was able to provide us with asphalt

production for the past three years, along with his estimate of the average production per year since the 1970s, which is available in Table 4.1.

Table 4.1 – Asphalt Production Estimates Per Year

Year	1997	1998	1999	Average per year
Asphalt Production (tons)	2,800,000	4,200,000	3,570,000	3,200,000

Cement Producer

We interviewed a cement producer to discuss the cement industry in Puerto Rico and its effect on the aggregate industry. He provided basic information pertaining to cement and its production as well as talking to us about his quarry.

During our interview, we discussed the Preference Law, or law number 109. This law is important to this project because it deals with the importation of cement from alternative sources as well as many other industries. Although the details of this law are not essential to this project, investigating a common misconception relating to cement importation is important to this project's outcome.

Simply stated, the Preference Law (for cement) states that all government construction projects that use concrete must utilize locally produced cement as long as the cost is no more than fifteen percent higher than concrete that includes imported cement. Although the percentage is company and industry specific, the purpose of this law is to benefit all local producers over products from foreign producers that are imported.

Currently, the Puerto Rican House of Representatives is conducting an investigation to see if this law has not been followed. Some claim that the government has purchased concrete that contains imported cement that at the purchased price, under law number 109, is illegal.

Many people feel the fact that there is an importer of cement, shows that the other two main producers, Puerto Rican Cement and Cemento San Juan, are unable to meet the demand for cement on the island. According to our contact, this is not the case. During our interview, he stated that not only are Cemento San Juan and Puerto Rican Cement able to fulfill the island's need for cement, but also stated that he is aware that his company is not even producing at 100 percent capacity.

We also discussed his quarry operations. He informed us that the material that he produces never becomes part of the aggregate market. He explained that all the aggregate his company produces is produced solely for the production of cement, and is never sold as aggregate. For this reason, his production numbers, as well as much of his quarry information was not relevant to the focus of this project.

DRNA

We interviewed a former Secretary of the DRNA in order to ask specific questions about the permitting process as well as practices of the DRNA.

The first series of questions dealt with the permitting process of the DRNA. The first question asked what the permitting process involves. He explained that the first step, submitting the permit application to the necessary division of the DRNA, could take from two to three weeks. It then takes six months to a year for the Department to review the

permit and determine whether an environmental impact statement is required. This type of document is required when the Department needs confirmation as to how the operation could impact the environment. This process, the impact statement, is intended to take three months, but can take up to a year. The former Secretary explained that the renewal process could take as long as the initial permitting process, if there are any major changes to the permit. Currently, operations are required to submit a request for the renewal of a permit three months, 90 days, before the expiration of the current permit. Unfortunately, the renewal process often lasts for over three months, which can cause problems for the quarry operations.

We asked him specifically why a permit only last three years. He explained that the DRNA does this in order to have more control over quarry operations. He stated that, in many cases, representatives do not go out into the field to oversee the operations, and the only time the quarry is evaluated is while reapplication of a permit is being processed. When asked, he assured us that the reason permits only last for three years has nothing to do with money; in fact he told us that the price of the permit only covers the cost to evaluate the application, and is not a source of income. In his opinion, since the EQB and EPA permits are for five years, it makes sense for the DRNA permits to last at least five years. However, he stated that while he was the Secretary, he made the same type of suggestion and it was not adopted.

He said that the employees of the DRNA are not fully qualified to make educated decisions regarding many of the technical aspects of the industry, such as blasting. He explained that, at its inception, the DRNA had numerous professionals and experts in many fields, ranging from geology and engineering. Over time, the DRNA lost many of

these experts. While he was in office, not a single mining engineer or blasting expert was employed by the DRNA.

He stated that the DRNA does not have the personnel or the budget to effectively govern everything that lies within its jurisdiction. For example, he stated that the DRNA does not have the necessary equipment to oversee field operations. He specifically said that the Mineral And Water Mineral Resources Division did not have a vehicle to navigate through a quarry, such as a jeep. He noted that the inadequate supplies hinder the ability of the DRNA to actively monitor operations. The questions and answers from this interview are available in Appendix C.

Planning Board

We interviewed the President of the Planning Board, José Caballero, in order to discuss how the Planning Board determines what the best use of land is as well as to discuss the permits issued by the Planning Board. The questions and answers from this interview are available in Appendix D.

The first topic discussed was Law Number 81, which was adopted in 1991. He explained that Law Number 81 gives each municipality the right to autonomy in local government and planning and zoning. The Planning Board is working with the individual municipalities in order to help them develop guidelines for land use plans. These land use plans are used to determine what the specific use of land should be. This law is taking some of the decisions away from the Central Planning Board and distributing some of the power to the individual planning boards of the different municipalities. The planners at the municipal level develop the guidelines for land use within their

municipality, and the Central Planning Board bases their final decisions on these guidelines.

We asked him how the best interests of the island are considered when the majority of the decisions are made on the municipal level. He explained that although the municipalities have the right to decide on land use, the Central Planning Board has the right to intervene if the use is not in the best interests of the island. For example, if a municipality decides that they will not zone an area for a quarry, and the island needs a quarry, the Central Planning Board has the authority to overrule the decisions of the municipality because the general interest of the island is best served by locating a quarry within the specific municipality. He stated that the Planning Board is aware of this type of problem, and assured us that all decisions will be made with the best interest of the island in mind.

Although the Central Planning Board has the authority to overrule decisions made by the municipal planning boards, the municipalities can challenge these rulings through the court system. If a decision by the Central Planning Board is brought to court by a municipality, the findings and decisions of the court are final.

We also discussed land use decisions with Mr. Caballero. He explained that when the Planning Board is accessing a specific land use application, different government agencies, such as the DRNA or Highway Department, submit reports to the Planning Board. These reports include the findings and recommendations of the specific agency, and are what the Planning Board uses to evaluate a permit. He stated that the reason this is done is to allow the most experienced agencies to make specific recommendations in

their area of expertise. It is the job of the Planning Board to weigh all the recommendations and to make a final determination.

Before any decisions can be made, the Planning Board must conduct public hearings. During these public hearings concerns of the public are discussed and often times analyzed. He stated that these hearings are often the most important step in the land use process. The Planning Board considers the opinions and concerns obtained from the public hearings when making a final decision.

We also discussed the permitting process. The process is similar to the land use process, in that all the agencies advise the Planning Board on their recommendations. The permitting process is a type of land use decision.

Total Production Of Aggregates

We analyzed the total production of aggregates in two ways as explained below. In addition to estimating the amount of current production of aggregates, we also calculated the maximum production capacity. The current production is the amount of aggregate that was produced in 1999 in order to meet the demand for the same year. The maximum production capacity is the total amount of aggregate that could be produced on the island if all producers extracted at their maximum daily limit set forth by the DRNA permit.

Current Aggregate Production

To acquire aggregate production totals we devised a spreadsheet survey for the members of AIPA. The survey asked for total production of aggregates in tons for 1999.

After distributing the survey at the AIPA meeting on April 5, 2000, as well as faxing a copy to each producing member of AIPA and following up with phone calls, we received responses from eight members.

Due to the low response rate, we relied heavily on the daily extraction limit set forth on the DRNA permit. The DRNA furnished us with a list of all the DRNA permitted extraction sites on the island. This information included the name of the company, the site's location as well as the maximum amount of extracted material allowed per day, as set forth by the permit. In addition, our liaison, Mr. Luis Terrassa, reviewed the DRNA list and modified some of the production numbers to better estimate current production on the island. We grouped operations according to the amount of aggregate that they extract daily. The groups were based on production numbers we received in response to our survey, in order to estimate the production amount of each group. We set up the groups in such a way that there was at least one verified production total per group. From the DRNA list, we added up the total number of operations within each group. Multiplying by the average yearly production reported in the survey for that size group yielded the total yearly production for each group. Totaling these production numbers gave us the total amount of current production of aggregates. These figures are presented in Table 4.2. The current production is the amount they actually produce, and is not the amount they are capable of producing.

Table 4.2 – Approximate Extraction Numbers for 1999, Obtained From Survey

Amount of Aggregate Extracted Daily (m^3)	Number of Operations	Average Verified Production Data for 1999 (tons)	Total Production (tons)
250 – 499	16	25,000	400,000
500-899	34	110,000	3,740,000
900-1100	16	160,000	2,560,000
1101-1500	6	200,000	1,200,000
1501-3000	9	350,000	3,150,000
3000+	5	500,000	2,500,000
Total	86	N/A	13,550,000

The total production numbers were lower than what was found to be the production number estimated from cement sales, as discussed below. The latter discrepancy was not surprising due to the inaccuracy of the two approximations. In addition, we analyzed the production numbers obtained from members of AIPA, and found that a few of the operations were not accounted for in the DRNA list. Although these specific operations are included due to the spreadsheet survey, it is likely that other operations are not included in the DRNA list, and are therefore not accounted for. We also found that there were operations on the DRNA list that are currently inactive and not producing.

Location of Aggregate Operations

We compiled data from the DRNA and MSHA in order to locate the current sand, gravel, and crushed stone operations on a map. The map, in Figure 4.1, shows the approximate location of operations on the island as well as the division of the seven

regions. Fill and base material operations are not included on this map, because they were not included in our calculations. A larger scale map that includes fill operations was presented to AIPA upon the conclusion of this project.

Maximum Production Capacity

We calculated the maximum production capacity in order to determine the amount of aggregate the island is capable of producing. This amount provides the basis for determining if the current facilities will be able to supply the demand for the future.

To calculate the maximum production capacity, we relied on the daily extraction limit set forth on the DRNA permit. According to Mr. Terrassa, producers operate their quarries for twenty days a month on average. Therefore, we multiplied the daily extraction number by 240, accounting for twenty days of work a month, and twelve months a year. This calculation yielded the maximum yearly extraction for each operation in cubic meters. We multiplied by the conversion factor of 1.6 to convert from cubic meters of aggregate to tons of aggregate per year. Finally, we totaled the yearly production of all the operations to yield the total maximum production capacity for the island.

The total production capacity for Puerto Rico is 33,128,064 tons per year. This figure excludes all fill operations and represents the amount of aggregate that would be produced on the island if all current producers extracted at their daily limit. This figure could be slightly inaccurate because the numbers were based on the DRNA list of permits. There are several operations that are not included on the DRNA list, as well as several inactive operations that are included on the list.

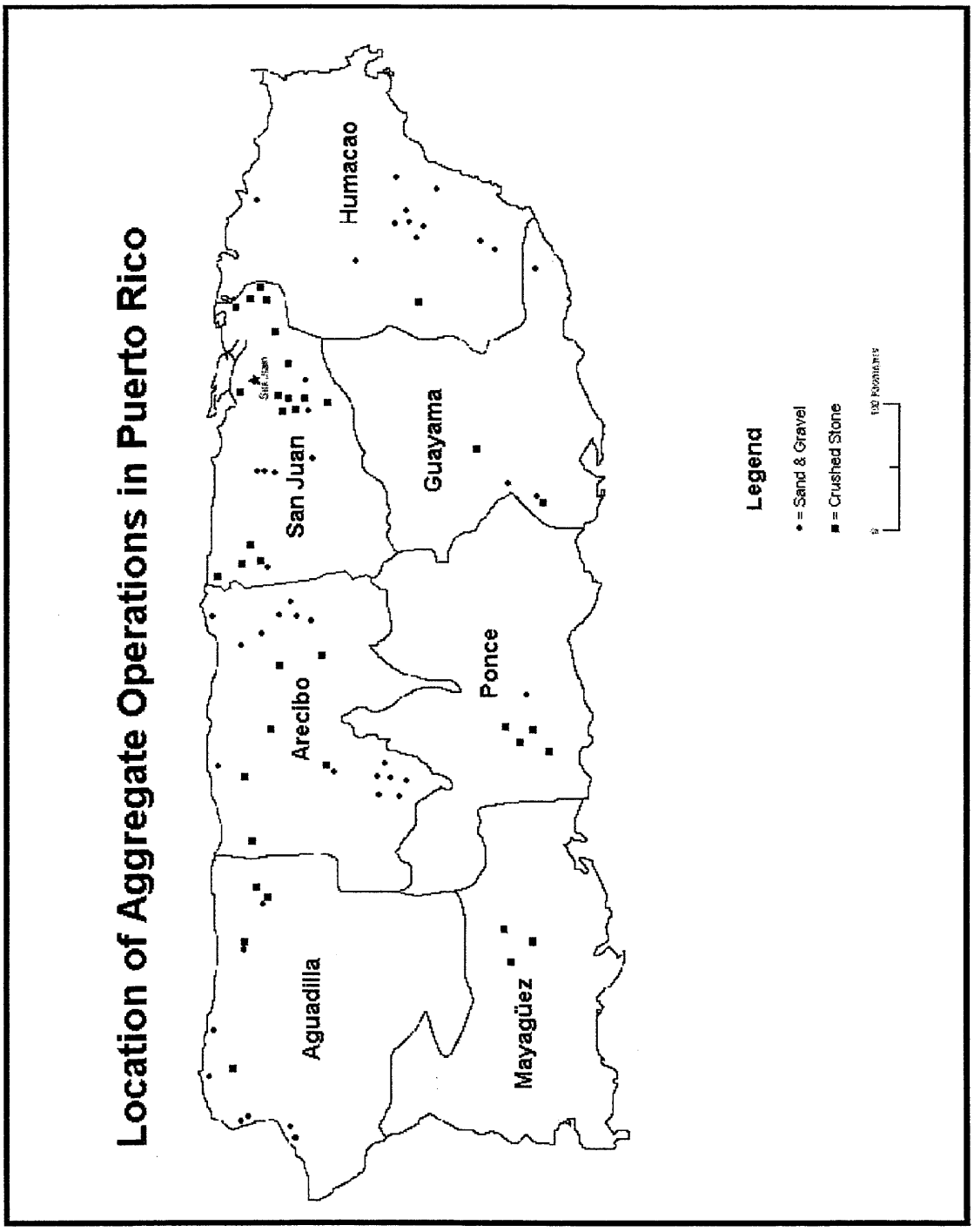


Figure 4.1 – Location of Aggregate Operations according to DRNA list

Table 4.3 illustrates the production totals for 1999 arranged into regions: Aguadilla, Arecibo, Guayama, Humacao, Mayagüez, Ponce and San Juan. These regions are based on regions set forth by the DRNA and the U.S. Geological Survey

Table 4.3 – Production Totals for 1999 by Region

Region	Total Extraction 1999 (tons)	Maximum Production Capacity (tons)
Aguadilla	1,575,000	3,264,000
Arecibo	2,420,000	3,942,144
Guayama	295,000	864,000
Humacao	2,700,000	6,798,720
Mayagüez	850,000	2,150,400
Ponce	1,775,000	6,278,400
San Juan	4,280,000	9,830,400
Puerto Rico	13,550,000	33,128,064

As Table 4.3 demonstrates, the majority of the producers in Puerto Rico are permitted to produce more than they produced in 1999.

Regression Analysis

In order to project the future demand for aggregates, we ran a series of regressions and analyzed each to obtain the best results. We ran these regressions to obtain an equation that could estimate and forecast the demand for aggregates. The estimated equation contained the variables that caused changes in the demand for aggregates in the

past, and so the variables chosen are likely to continue to cause changes in the future. We utilized Microsoft Excel to run our regressions.

The main indicators that were analyzed to determine which regression was the best were the R-squared value, as well as the P-value and the T-statistic. The R-squared value, or coefficient of determination, is interpreted as the percentage of the change in the dependent variable associated with the change in the independent variables. An acceptable R-squared value is above 0.80; however the closer to one the better. An R-squared value of one implies that every single one of data points lies on the best-fit regression line and that there is a 100 percent correlation between the dependent and independent variables. The T-statistic is used to measure the likelihood that a relationship is random and not related. The higher the T-statistic, the better the relationship. The T-statistic must have the correct sign, for example if there is a direct positive relationship between two variables, the T-statistic must be positive. The value of the T-statistic determines the P-value. The latter is a measure of whether the relationship arrived at was purely by chance and that there is no correlation between the numbers. Any P-value below 0.05 is considered acceptable.

Variables

In order to perform a meaningful regression analysis and obtain a useful equation, we first had to decide what possible variables to use. Once we determined what variables we would use, we needed to determine which variables depended on which variables, and then break them down into independent and dependent variables.

Independent Variables

We chose independent variables that were most likely to affect the consumption of aggregates. The independent variables included trend, population, GDP, GDP per capita, mortgage rate, bank prime loan rate, construction investment, construction cost index, GDP percent change, and GDP per capita percent change. All economic variables are measured in constant 1954 dollars. The trend variable is a measure of time, assigning the value two to the year 1971 and augmented by one in each subsequent year.

Our choice of variables was based upon knowledge of the factors that affect the demand for aggregates. Throughout our interviews, we learned that aggregates are the most important component for construction in Puerto Rico, and so the demand for aggregates is heavily influenced by the amount of construction. We chose GDP-related variables because when the economy is strong, people and the government tend to invest more in growth, including buildings, houses and roadways. Similarly, when the mortgage rates are low, investment in housing increases because the cost of money is the major cost of home ownership. We included the bank prime loan rate for the same reason. In addition, it is logical to assume that as population increases, so does construction activity and construction investment because there is a greater need for housing.

We obtained data for these variables from the Planning Board and the Government Development Bank for Puerto Rico. The numbers needed to be analyzed and manipulated before their use in the regression analysis. In order to reduce the effects of inflation on all monetary variables, we obtained these values in constant 1954 dollars. This process effectively puts all monetary variables on the same scale, 1954 dollars.

Both GDP and construction investment were in terms of 1954 dollars for all of the regressions.

Dependent Variables

In order to forecast the demand for aggregate consumption, we needed to have aggregate consumption as a dependent variable. Since no real production or consumption numbers exist for aggregates in Puerto Rico, we used cement sales to obtain approximate aggregate consumption numbers and accounted for asphalt sales following the regression.

Cement Sales

We based aggregate consumption on cement bag sales. For our purposes, we considered aggregate consumption to be the amount of aggregate included in concrete. Therefore, we used the amount of total cement sales per year to calculate the amount of concrete produced. In our calculations, we assumed the weight of water in concrete to be negligible. We took the number of cement bags sold and divided by 4.5, the number, according to the cement producer, of 94 pound cement bags in a cubic yard of concrete, producing the total volume of concrete sold in cubic yards. According to the cement producer, since one cubic yard of concrete weighs approximately two tons, we multiplied the volume of concrete obtained by two to obtain the total weight of the concrete produced in tons. To take into account the weight of the cement, we first found the weight of one bag of cement in tons. Since each bag of cement weighs 94 pounds and one ton is 2,000 pounds, a bag of cement weights 94/2000 or .047 tons. Multiplying this number by the total number of cement bag sales yields the total weight of cement in concrete. Subtracting this number from the total weight of concrete results in the total

weight of aggregate, in tons, of all concrete produced on the island per year, as can be seen in Equation 4.1.

Since the vast majority of aggregates are used in concrete, other types of uses such as fill and base material are not considered in this project.

Equation 4.1 – Conversion from Cement Bags to Tons of Aggregate

$$Aggregate\ Weight\ (tons) = \frac{\#\ Bags\ Cement}{4.5} \times 2 - .047 \times \#\ Bags\ Cement$$

Asphalt Sales

The production of asphalt is also a major factor in aggregate consumption and must be accounted for in the regression analysis. The data for asphalt sales was only available for the past three years and so we could not account for asphalt sales in our calculation of aggregate consumption. Therefore, we accounted for asphalt sales by adding approximate asphalt sales to the final forecasted amounts of aggregate consumption. We used asphalt production data from 1999 because, of the available data, the 1999 figures were the most representative of an average year of asphalt production. We multiplied the 1999 asphalt production times 0.95, because ninety-five percent of asphalt is aggregate. We then divided the product by the 1999 aggregate production to find the percent ratio of asphalt to aggregate. The result was 19.3 percent. We increased the forecasted aggregate production each year from 2000 until 2010 by 19.3 percent to account for asphalt. The resulting aggregate production includes the aggregate in asphalt as well as that in concrete. The modification of aggregate consumption to account for

asphalt sales will be discussed in further detail in the section titled *Projected Total Aggregate Consumption.*

Determining the Best-Fit Regression

In order to project the best possible values for aggregate demand we first had to determine the best-fit regression. We tried many combinations of independent variables to determine the best relationship.

To determine the best variables, we first ruled out any combinations of independent variables that were dependent upon each other. For example, population is accounted for in GDP so these variables would correlate too closely and yield poor results. Also excluded were any independent variables whose estimated relationship with the dependent variable was not logical. Population, for example, showed a negative relationship with aggregate consumption, indicating that aggregate consumption decreases as population increases. Logically, you would expect an upward trend in aggregate consumption, so we eliminated population by itself as an independent variable. However, GDP was included in the final equation, and since GDP is the product of GDP per capita and population, population has an indirect influence on aggregate demand. In other words, in our model population growth effects aggregate demand by increasing total GDP.

Two-Step Regression

We began our regression trials using a two-step process. We first regressed construction investment against mortgage rate, trend and GDP. Then we regressed aggregate consumption against construction investment. The logic behind the two-step

process was based on the assumption that aggregate consumption is largely dependent upon construction investment, and that construction investment is largely dependent upon GDP and mortgage rates. These variables produced the best-fit two-step regression.

In the first step of the two-step regression, construction investment in constant 1954 dollars was regressed against a trend variable starting at two, GDP in constant 1954 dollars and mortgage rates from the year 1971 until the year 1999. This led to an equation that calculates construction investment in terms of the trend variable, GDP and mortgage, as seen below in Equation 4.2. Included with the equation are some important test statistics for that particular regression and equation. The t-statistic value is reported in parentheses under its respective coefficient, and the R-squared value for the regression is reported below the t-statistics.

Equation 4.2 – Equation Obtained from First Step of Two-Step Regression

$$\text{Constr. Inv.} = -159664654 + -61740809.28 \times \text{Trend} + 0.31970217 \times \text{GDP} + -13826477.72 \times \text{Mortgage}$$

(-1.201) (-8.851) (9.460) (-2.311)

R-Squared = .904

Then, as the second step in the two-step regression, aggregate consumption was regressed against construction investment. This led to an equation (Equation 4.3) relating construction investment to aggregate consumption, with the test statistics as seen below.

Equation 4.3 – Equation Obtained from Second Step of Two-Step Regression

$$\text{Agg. Cons.} = 7098006.101 - 110276.349 \times \text{Trend} + 0.013 \times \text{Constr. Inv.}$$

(12.789) (-4.919) (12.942)

R-Squared = .866

We then substituted the first equation that relates trend, GDP and mortgage to construction investment into the second equation in place of construction investment. Solving these two equations gave a third equation that yields aggregate consumption in terms of the trend variable, GDP and mortgage. This equation (Equation 4.4) is listed below.

Equation 4.4 – Equation Obtained from Substituting Step One Into Step Two of Two-Step Regression

$$Agg.\ Cons. = 5022365.598 - 912905.821 \times Trend + 0.004 \times GDP - 179744.210 \times Mortgage$$

One-Step Regression

The two steps were then combined into a one step process. The result was a one-step process regressing aggregate consumption against trend, mortgage and GDP. The single step regression regressed aggregate consumption against the trend variable, GDP per constant 1954 dollars and mortgage. This regression produced the best-fit single step regression with the following equation (Equation 4.5) and test statistics.

Equation 4.5 – Equation Obtained from One-Step Regression Analysis

$$\underset{}{Agg.Cons.} = \underset{(3.300)}{5871994.805} - \underset{(-9.635)}{923424.043} \times Trend + \underset{(9.198)}{0.004} \times GDP - \underset{(-3.232)}{259753.996} \times Mortgage$$

$$R\text{-}Squared = .896$$

Comparison of Two-Step and One-Step Regression

We compared the results from the one-step regression to those of the two-step regression to determine the better process. The analysis of both the one-step and the two-

step process was quantitative and required a basic understanding of the variables and their effect on the other variables, as well as a simple understanding of the aggregate market and what affects it.

To compare these two final analyses, we considered many factors. Among these factors was the effect that construction activity might have on the analysis. We decided that since we could not compare the R-squared values because one was a two-step analysis and the other was a one-step analysis, we would have to investigate both the P-values and the T-statistics; however, the values for all the regressions were very similar. For this reason, we analyzed how the different variables would affect one another. We concluded that the two-step process has a larger margin of error due to the fact that it included construction investment. We felt that construction investment and aggregate consumption are often times dependent on one another. That is, construction investment affects aggregate consumption and aggregate consumption affects construction investment. With this in mind, we decided that the one-step process that regressed aggregate consumption on a trend variable, GDP and mortgage was the better of the two.

One-Step Log Linear Regression

After concluding that the one-step regression would produce the best results, we used the same variables and analyzed them using a log linear regression. We expected that the log linear regression might produce better results than a linear regression. However, when we took the natural logarithm of trend, the natural logarithm of GDP, the natural logarithm of mortgage and the natural logarithm of aggregate consumption, the statistical values were unacceptable for this project.

We then ran a regression of the natural logarithm of aggregate consumption on the trend variable, the natural logarithm of GDP and the natural logarithm of mortgage; and the R-squared value, T-statistic and P-value were much better. The only difference was that in this equation the effect of the trend variable is exponential. The coefficient of the trend term was negative in all of the regressions indicating that construction activity has been decreasing relative to GDP since 1970. It is not logical to assume that this decline will continue indefinitely at an exponential rate as the log linear regressions suggest. On the other hand, the linear equation forecasts that the effect of time will decline in percentage terms over future years, which makes more sense. The Microsoft Excel outputs are available in Appendix F.

Then we projected future aggregate consumption values using the log linear equation. We obtained decreasing aggregate consumption numbers over time, despite increasing GDP, as shown in Table 4.4. Since this equation obviously yields illogical results, we concluded that the one-step linear regression was the best equation to forecast aggregate consumption.

Table 4.4 – Project Aggregate Consumption From Log Linear One-Step Regression

Year	Aggregate Consumption (tons)
2000	14,176,151
2001	14,245,463
2002	14,230,427
2003	14,173,267
2004	14,114,264
2005	14,015,590
2006	13,918,016
2007	13,862,411
2008	13,765,813
2009	13,710,072
2010	13,694,203

Forecasting Demand For Aggregates

A projection of future demand for aggregates is helpful to aggregate producers throughout the island. Based on these projections, producers can prepare for any changes in the market in the coming years. In addition, they will have data to support arguments to the DRNA to obtain new permits. The regression analysis was used as the basis for our projections.

The one-step linear regression yielded the best results, and therefore we used the equation found in Equation 4.5, which was produced by the one-step linear regression, to forecast the demand for aggregates.

With this equation, we were able to estimate future demand for aggregates using estimated future values of GDP and the mortgage rate. The projected GDP constant values for the years 2000 through 2010 we obtained from the Planning Board, and we

estimated the mortgage rate to be eight percent for all of these years. Our estimation of mortgage rate was based on the feelings of most financial analysts that the mortgage rate would climb at least slightly over the coming years. The projected GDP and mortgage rate values are shown in Table 4.5.

Table 4.5 – Projected Independent Variables

Year	*Trend*	*GDP (Dollars)*	*Mortgage Rate (%)*
2000	*31*	*9,944,000,000.00*	*8*
2001	*32*	*10,352,000,000.00*	*8*
2002	*33*	*10,756,000,000.00*	*8*
2003	*34*	*11,165,000,000.00*	*8*
2004	*35*	*11,589,000,000.00*	*8*
2005	*36*	*12,018,000,000.00*	*8*
2006	*37*	*12,463,000,000.00*	*8*
2007	*38*	*12,937,000,000.00*	*8*
2008	*39*	*13,416,000,000.00*	*8*
2009	*40*	*13,926,000,000.00*	*8*
2010	*41*	*14,469,000,000.00*	*8*

Source: Junta de Planificación

We substituted the projected values of these variables for the independent variables (Table 4.5) in the equation (Equation 4.5) to yield the projected aggregate consumption of the years 2000 through 2010. We used the same process to estimate past consumption from 1971 to 1999. We calculated the past estimates in order to verify that the results were accurate. As illustrated in Table 4.6, our estimates were fairly close to the actual aggregate consumption numbers, demonstrating that the equation was relatively precise. The italicized numbers are the projected values for the years 2000 through 2010.

Table 4.6 – Estimated Aggregate Consumption and Actual Consumption per Year

Year	Agg. Cons. (estimated) (tons of aggregate)	Agg. Cons. (actual) (tons of aggregate)
1971	15,688,941	14,880,818
1972	15,770,350	16,128,346
1973	15,424,343	16,656,525
1974	14,314,446	15,639,736
1975	13,104,180	13,491,546
1976	13,008,619	12,595,731
1977	13,046,306	11,489,355
1978	12,948,900	12,047,590
1979	12,432,191	11,881,041
1980	11,369,557	11,733,347
1981	9,945,146	10,744,924
1982	9,289,904	8,671,483
1983	8,554,449	7,653,486
1984	9,060,692	8,380,756
1985	9,165,868	8,700,308
1986	9,626,718	9,013,881
1987	10,263,182	11,227,685
1988	10,987,708	11,845,109
1989	11,048,606	11,976,121
1990	11,452,711	12,287,196
1991	11,393,973	12,097,987
1992	11,980,230	11,938,170
1993	12,706,221	12,102,437
1994	12,808,728	12,670,691
1995	13,453,702	13,117,283
1996	13,342,802	13,946,560
1997	14,159,683	14,957,052
1998	15,761,902	15,385,841
1999	17,566,777	16,415,835
2000	*16,645,872*	
2001	*17,424,283*	
2002	*18,186,009*	
2003	*18,968,591*	
2004	*19,813,741*	
2005	*20,679,746*	
2006	*21,612,490*	
2007	*22,666,198*	
2008	*23,740,761*	
2009	*24,944,631*	
2010	*26,286,149*	

Total Projected Aggregate Consumption

The projected values of aggregate consumption in Table 4.6 do not account for aggregate included in asphalt production. As stated earlier, the projected values of aggregate consumption were increased by the percent of asphalt aggregate consumption compared to total aggregate consumption for 1999, which was 19.3 percent. The final values for aggregate consumption, including aggregate used in asphalt manufacturing, are show in Table 4.7. These values represent the amount of aggregate that will be needed for concrete and asphalt production for the years 2000 through 2010. These values do not include the aggregate necessary for base and fill material. However, the aggregate production calculations also do not include production of base and fill material.

Table 4.7 – Total Aggregate Consumption Including Asphalt per Year

Year	Aggregate Consumption Total (tons)
1971	18,716,907
1972	18,814,028
1973	18,401,242
1974	17,077,134
1975	15,633,287
1976	15,519,283
1977	15,564,243
1978	15,448,038
1979	14,831,604
1980	13,563,882
1981	11,864,559
1982	11,082,855
1983	10,205,458
1984	10,809,406
1985	10,934,880
1986	11,484,674
1987	12,243,976
1988	13,108,336
1989	13,180,986
1990	13,663,084
1991	13,593,010
1992	14,292,414
1993	15,158,522
1994	15,280,813
1995	16,050,266
1996	15,917,963
1997	16,892,502
1998	18,803,949
1999	20,957,165
2000	*19,858,526*
2001	*20,787,170*
2002	*21,695,909*
2003	*22,629,530*
2004	*23,637,793*
2005	*24,670,937*
2006	*25,783,701*
2007	*27,040,774*
2008	*28,322,728*
2009	*29,758,945*
2010	*31,359,376*

Projection Of Aggregate Consumption Per Municipality

We forecasted the aggregate consumption for each municipality in order to show the areas with the most demand, therefore the areas requiring more aggregate production facilities. The projections were based on population forecasts per municipality, forecasted by the Planning Board, which were the only projected data available per municipality. Population is indirectly accounted for in the regression through GDP, which can be viewed as the product of GDP per capita and population. Additionally, although population is not a reliable variable on the island-wide scale, aggregate production is more closely related to population on the municipal level. When analyzing the entire island, the much of the construction is on building and businesses, not homes. With this type of island-wide scale, economic variables have more of an effect on construction, and therefore aggregate production, than population. On the municipal level however, the majority of construction is building housing. Since the number of houses relies heavily on population, then population would greatly affect the amount of aggregates consumed for construction. Therefore, it is reasonable to use population as a variable to forecast aggregate consumption per municipality and to expect accurate results.

We obtained the forecasted population for each municipality for the year 2000 through the year 2010. These figures are arranged by region and reported in Table 4.8 through Table 4.15. The division of regions is based on the DRNA and U.S. Geological Survey divisions, and is the same division that was used throughout the entire project.

The forecasted populations are reported for each municipality and are also totaled for each region.

Table 4.8 – Projected Population Per Municipality in the Aguadilla Region

Municipality	Region	1990	1995	2000	2005	2010
Aguada	Aguadilla	35,911	37,858	39,536	41,122	42,490
Aguadilla	Aguadilla	59,335	61,742	63,511	65,078	66,279
Anasco	Aguadilla	25,234	26,110	27,057	27,953	28,647
Camuy	Aguadilla	28,917	30,455	32,061	33,592	34,850
Hatillo	Aguadilla	32,703	34,435	35,773	36,960	37,957
Isabella	Aguadilla	39,147	40,150	41,215	42,211	42,936
Lares	Aguadilla	29,015	30,281	31,256	32,154	32,869
Las Marias	Aguadilla	9,306	9,725	10,133	10,558	10,858
Moca	Aguadilla	32,926	34,577	36,335	38,019	39,449
Quebradillas	Aguadilla	21,425	22,420	23,196	23,880	24,407
Rincon	Aguadilla	12,213	12,662	13,192	13,747	14,133
Total	Aguadilla	326,132	340,415	353,265	365,274	374,875

Table 4.9 – Projected Population Per Municipality in the Arecibo Region

Municipality	Region	1990	1995	2000	2005	2010
Arecibo	Arecibo	93,385	96,826	100,228	103,028	104,813
Barceloneta	Arecibo	20,947	21,996	22,801	23,474	23,973
Ceilas	Arecibo	18,084	18,885	19,672	20,488	21,075
Florida	Arecibo	8,689	9,182	9,565	9,964	10,248
Jayuya	Arecibo	15,527	16,133	16,804	17,507	18,009
Manati	Arecibo	38,692	40,261	41,373	42,343	43,074
Morovis	Arecibo	25,288	27,017	28,556	30,076	31,490
Naranjito	Arecibo	27,914	30,022	31,838	33,605	35,261
San Sebastian	Arecibo	38,799	39,962	41,257	42,568	43,599
Utuado	Arecibo	34,980	35,971	36,561	37,043	37,316
Vega Alta	Arecibo	34,559	37,557	40,177	42,611	44,826
Vega Baja	Arecibo	55,997	59,474	62,466	65,362	67,998
Total	Arecibo	412,861	433,286	451,298	468,069	481,682

Table 4.10 – Projected Population Per Municipality in the Guayama Region

Municipality	Region	1990	1995	2000	2005	2010
Aibonito	Guayama	24,971	26,213	27,185	28,122	28,957
Arroyo	Guayama	18,910	19,832	20,660	21,527	22,137
Caguas	Guayama	133,447	140,988	146,858	151,866	155,910
Cayey	Guayama	46,553	49,399	51,758	53,836	55,588
Cidra	Guayama	35,601	38,425	41,044	43,631	46,104
Comerio	Guayama	20,265	21,099	21,978	22,899	23,551
Guayama	Guayama	41,588	42,738	44,018	45,278	46,246
Gurabo	Guayama	28,737	30,831	32,666	34,420	36,078
Juncos	Guayama	30,612	32,696	34,491	36,192	37,744
Maunabo	Guayama	12,347	12,840	13,379	13,939	14,331
Patillas	Guayama	19,633	20,552	21,411	22,310	22,943
Yabucoa	Guayama	36,483	38,747	40,743	42,655	44,378
Total	Guayama	449,147	474,360	496,191	516,675	533,967

Table 4.11 – Projected Population Per Municipality in the Humacao Region

Municipality	Region	1990	1995	2000	2005	2010
Canovanas	Humacao	36,816	39,064	41,020	42,832	44,425
Ceiba	Humacao	17,145	17,782	18,522	19,293	19,843
Culebra	Humacao	1,542	1,644	1,716	1,784	1,838
Fajardo	Humacao	36,882	36,943	38,420	39,728	40,890
Humacao	Humacao	55,203	59,220	62,889	66,358	69,478
Las Piedras	Humacao	27,896	29,977	31,898	33,814	35,621
Loiza	Humacao	29,307	32,720	36,410	40,383	44,628
Luquillo	Humacao	18,100	18,897	19,681	20,507	21,090
Naguabo	Humacao	22,620	23,711	24,613	25,498	26,304
Rio Grande	Humacao	45,648	49,559	53,808	58,172	62,478
San Lorenzo	Humacao	35,163	36,665	37,752	38,717	39,487
Vieques	Humacao	8,602	8,990	9,367	9,760	10,039
Total	Humacao	334,924	355,172	376,096	396,846	416,121

Table 4.12 – Projected Population per Municipality in the Mayagüez Region

Municipality	Region	1990	1995	2000	2005	2010
Cabo Rojo	Mayagüez	38,521	39,907	40,803	41,554	42,108
Guanica	Mayagüez	19,984	20,922	21,796	22,707	23,353
Guyanilla	Mayagüez	21,581	22,382	23,211	23,975	24,568
Hormigueros	Mayagüez	15,212	15,803	16,462	17,157	17,648
Lajas	Mayagüez	23,271	23,890	24,608	25,356	25,944
Maricao	Mayagüez	6,206	4,770	4,968	5,173	5,321
Mayagüez	Mayagüez	100,371	103,382	106,303	108,471	109,654
Penuelas	Mayagüez	22,515	24,173	25,958	27,825	29,653
Sabana Grande	Mayagüez	22,843	23,650	24,574	25,542	26,352
San German	Mayagüez	34,962	36,140	36,860	37,412	37,768
Yauco	Mayagüez	42,058	44,414	46,839	49,112	51,027
Total	Mayagüez	307,456	317,014	327,543	337,177	344,379

Table 4.13 – Projected Population Per Municipality in the Ponce Region

Municipality	Region	1990	1995	2000	2005	2010
Adjuntas	Ponce	19,451	20,200	21,041	21,925	22,551
Barranquitas	Ponce	25,605	27,631	29,403	31,128	32,751
Coamo	Ponce	33,837	35,217	36,729	38,247	39,542
Juana Diaz	Ponce	45,198	47,229	49,326	51,222	52,705
Orocovis	Ponce	21,158	22,391	23,394	24,333	25,166
Ponce	Ponce	187,749	191,502	195,620	200,366	202,611
Salinas	Ponce	28,335	29,378	30,531	31,677	32,613
Santa Isabel	Ponce	19,318	18,175	17,025	16,144	16,604
Villalba	Ponce	23,559	25,252	27,019	28,765	30,383
Total	Ponce	404,210	416,975	430,088	443,807	454,926

Table 4.14 – Projected Demand Per Municipality in the San Juan Region

Municipality	Region	1990	1995	2000	2005	2010
Aguas Buenas	San Juan	25,424	26,898	28,159	29,322	30,319
Bayamón	San Juan	220,262	234,119	244,045	251,507	256,617
Carolina	San Juan	177,806	185,339	192,534	198,374	202,305
Cataño	San Juan	34,587	38,151	41,392	44,649	47,923
Corozal	San Juan	33,095	35,536	37,729	39,904	41,889
Dorado	San Juan	30,759	33,108	35,182	37,124	38,846
Guaynabo	San Juan	92,886	97,941	101,635	104,747	107,309
San Juan	San Juan	437,745	451,096	455,595	457,108	456,639
Toa Alta	San Juan	44,101	49,384	54,414	59,482	64,554
Toa Baja	San Juan	89,454	95,750	100,892	105,334	108,956
Trujillo Alto	San Juan	61,120	65,022	69,057	72,925	76,345
Total	San Juan	1,247,239	1,312,344	1,360,634	1,400,476	1,431,702

Table 4.15 – Projected Population for Puerto Rico

Municipality	Region	1990	1995	2000	2005	2010
Puerto Rico	Puerto Rico	3,522,037	3,691,985	3,839,954	3,975,431	4,086,669

Aggregates are the main component in concrete, which constitutes the majority of all construction materials. As population increases, the demand for housing and other buildings rise, creating an increase in the demand for construction materials. For this reason, it is legitimate to assume that population drives the demand for aggregates in a specific, small market. Therefore, we assumed that the localities with the highest projected population increase would experience the greatest demand for aggregates and the greatest aggregate consumption.

We calculated the percent population change per municipality with respect to the population change on the island. This calculation produced a ratio of change in population of the specific municipality to the change in population of the entire island. This computation gives the percent change in population of a municipality with respect to the entire island. By multiplying this percent by the forecasted aggregate consumption for the island, we obtained the forecasted aggregate demand per municipality. This method required the assumption that each municipality's share of aggregate consumption is equal to their share of total population growth, therefore generating a one-to-one ratio. Tables 4.16 through 4.23 show the percent population change with respect to the population change of the island along with the projected demand for aggregates for each municipality. These statistics are also totaled by region and included in these tables.

Table 4.16 – Projected Aggregate Demand Per Municipality in the Aguadilla Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Aguada	Aguadilla	1.20	375,476
Aguadilla	Aguadilla	1.12	351,834
Añasco	Aguadilla	0.64	202,101
Camuy	Aguadilla	1.13	354,503
Hatillo	Aguadilla	0.89	277,603
Isabella	Aguadilla	0.70	218,752
Lares	Aguadilla	0.65	205,025
Las Marias	Aguadilla	0.29	92,153
Moca	Aguadilla	1.26	395,813
Quebradillas	Aguadilla	0.49	153,927
Rincon	Aguadilla	0.38	119,608
Total	Aguadilla	8.76	2,746,797

Table 4.17 - Projected Aggregate Demand Per Municipality in the Arecibo Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Arecibo	Arecibo	1.86	582,789
Barceloneta	Arecibo	0.48	148,970
Ceilas	Arecibo	0.57	178,332
Florida	Arecibo	0.28	86,815
Jayuya	Arecibo	0.49	153,165
Manati	Arecibo	0.69	216,210
Morovis	Arecibo	1.19	372,934
Naranjito	Arecibo	1.39	435,090
San Sebastian	Arecibo	0.95	297,686
Utuado	Arecibo	0.31	95,966
Vega Alta	Arecibo	1.88	590,924
Vega Baja	Arecibo	2.24	703,160
Total	Arecibo	12.32	3,862,040

Table 4.18 – Projected Aggregate Demand Per Municipality in the Guayama Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Aibonito	Guayama	0.72	225,235
Arroyo	Guayama	0.60	187,738
Caguas	Guayama	3.67	1,150,579
Cayey	Guayama	1.55	486,822
Cidra	Guayama	2.05	643,165
Comerio	Guayama	0.64	199,940
Guayama	Guayama	0.90	283,196
Gurabo	Guayama	1.38	433,691
Juncos	Guayama	1.32	413,481
Maunabo	Guayama	0.39	121,007
Patillas	Guayama	0.62	194,729
Yabucoa	Guayama	1.47	462,036
Total	Guayama	15.31	4,801,620

Table 4.19 – Projected Aggregate Demand Per Municipality in the Humacao Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Canovanas	Humacao	1.38	432,802
Ceiba	Humacao	0.54	167,909
Culebra	Humacao	0.05	15,507
Fajardo	Humacao	1.00	313,956
Humacao	Humacao	2.67	837,513
Las Piedras	Humacao	1.51	473,222
Loiza	Humacao	3.33	1,044,571
Luquillo	Humacao	0.57	179,095
Naguabo	Humacao	0.69	214,939
Rio Grande	Humacao	3.51	1,102,024
San Lorenzo	Humacao	0.70	220,532
Vieques	Humacao	0.27	85,416
Total	Humacao	16.22	5,087,486

Table 4.20 – Projected Aggregate Demand Per Municipality in the Mayagüez Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Cabo Rojo	Mayagüez	0.53	165,876
Guanica	Mayagüez	0.63	197,907
Guyanilla	Mayagüez	0.55	172,485
Hormigueros	Mayagüez	0.48	150,750
Lajas	Mayagüez	0.54	169,816
Maricao	Mayagüez	0.14	44,869
Mayagüez	Mayagüez	1.36	425,938
Penuelas	Mayagüez	1.50	469,663
Sabana Grande	Mayagüez	0.72	225,997
San German	Mayagüez	0.37	115,414
Yauco	Mayagüez	1.70	532,327
Total	Mayagüez	8.52	2,671,041

Table 4.21 – Projected Aggregate Demand Per Municipality in the Ponce Region

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Adjuntas	Ponce	0.61	191,933
Barranquitas	Ponce	1.36	425,557
Coamo	Ponce	1.14	357,554
Juana Diaz	Ponce	1.37	429,497
Orocovis	Ponce	0.72	225,235
Ponce	Ponce	2.83	888,610
Salinas	Ponce	0.84	264,638
Santa Isabel	Ponce	-0.17	0
Villalba	Ponce	1.36	427,590
Total	Ponce	10.07	3,157,101

Table 4.22 – Projected Aggregate Demand Per Municipality in the San Juan Area

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Aguas Buenas	San Juan	0.88	274,553
Bayamón	San Juan	5.10	1,597,998
Carolina	San Juan	3.96	1,241,969
Catano	San Juan	2.65	830,140
Corozal	San Juan	1.69	528,768
Dorado	San Juan	1.49	465,723
Guaynabo	San Juan	2.30	721,209
San Juan	San Juan	0.42	132,700
Toa Alta	San Juan	4.11	1,288,872
Toa Baja	San Juan	3.27	1,024,996
Trujillo Alto	San Juan	2.95	926,361
Total	San Juan	28.81	9,033,290

Table 4.23 – Projected Aggregate Demand in Puerto Rico

Municipality	Region	2000-2010 Respective Growth	2010 Demand Per Municipality (in tons)
Puerto Rico	Puerto Rico	100.00	31,359,376

In Table 4.16 through Table 4.23, the projected demand for aggregate in tons per municipality as well as per region is established. Although these numbers are not exact, because of the calculation's high dependency on population, they are the best estimate that can be obtained. That is, since population is not the only variable that affects aggregate consumption (as shown in the regression analysis), and therefore these numbers are just rough estimates.

To demonstrate this point more clearly, in Table 4.21, a municipality called Santa Isabel appears to have no demand for aggregates. Physically, this would mean that there is no construction in the region.

As it turns out, once all the calculations were completed, Santa Isabel's demand for aggregates was –53,312 tons of aggregate. Physically, this would mean that the municipality is producing more aggregates than they consume and selling the surplus (53,512 tons worth) to the rest of the island, or they would be deconstructing buildings and houses and selling the aggregates. Clearly, neither of these cases is true. The explanation for this negative number lies in the population projections for this municipality.

As demonstrated in Table 4.21 and Table 4.13, the population of Santa Isabel is projected to drop .17 percent by the year 2010, which means that the population of this municipality will decrease slightly. Our calculation account for this decrease in population by adding a negative sign to the value of aggregate consumption.

In reality, however, the demand would not be negative it would be zero. That is, although the calculation expresses a negative demand, physically this is not possible. Since the population of Santa Isabel is not projected to increase, then the demand for aggregates would be zero. There would be no new construction of houses and other buildings due to this decrease in population. This is why Table 4.21 illustrates a demand of zero to the municipality of Santa Isabel.

Supply-Demand Comparison

The calculation of projected demand per region can be compared to current production of aggregates to determine the areas that will require an increase in the production of aggregates. Table 4.24 compares the projected demand per region with the current production for each respective region.

Table 4.24 – Projected Aggregate Demand and Current Production Per Region

Region	Projected Demand in 2010 (tons)	Current Maximum Production Capacity (tons)
Aguadilla	2,746,797	3,264,000
Arecibo	3,862,040	3,942,144
Guayama	4,801,620	864,000
Humacao	5,087,486	6,789,720
Mayagüez	2,671,041	2,150,400
Ponce	3,157,101	6,278,400
San Juan	9,033,290	9,830,400
Puerto Rico	31,359,376	33,128,064

As Table 4.24 demonstrates, many of the regions of Puerto Rico will be close to, if not over, their maximum aggregate production capacity. As the table illustrates, the production numbers, assuming they do not change, will be at their maximum capacity due to the demand. This information suggests that soon after 2010, the demand for aggregates will exceed the possible supply, and something will need to be done in order to meet this demand for aggregates.

In Guayama and Mayagüez, the demand will have already exceeded the maximum aggregate production for each region by the year 2010. This data demonstrates that unless something is done to remedy this situation, both regions will not be able to supply enough aggregate to meet the demand. Some facilities in the Ponce and Humacao

regions might be close enough to supply the areas in the Guayama region. Similarly, facilities in the Ponce region may be able to supply areas in the Mayagüez region.

Although Table 4.24 shows what production numbers are estimated to be for the year 2010, many different factors will affect these numbers between now and 2010. For example, many of these operations may be able to increase the maximum daily allowable limit on their permit, while others may be able to increase production due to better technological advances, which could lower certain costs. Additionally, newer operations may be opened between now and 2010 that would increase the supply of aggregates. In addition, operations from outside the region may begin to sell aggregates in different regions, if demand is high enough to cover the transportation costs.

Case Study

To help illustrate the existing and potential problems of the aggregate industry, we studied the quarries in one area of the island, and made projections for another area. Our first choice, in the southern side of Puerto Rico has already had problems with the encroachments of residential developments. Our second choice, the municipality of Bayamón, is projected to have the greatest increase in population on the island which could lead to problems with new residential developments in the vicinity of already existing quarries.

Southern Area

A major problem in the aggregate industry is the increasing difficulty in retaining and renewing permits and acquiring permits for new extraction locations. Several

quarries have been shut down by the DRNA for various reasons. The most common reasons for which the DRNA has prohibited extraction at existing quarries include the discovery of protected natural resources in the area, such as cave systems, the conflict with residential development in the surrounding communities, and the violation of permit regulations. The halt in production decreases the supply of aggregates and, over long periods of time, could affect the community, the economy, and construction.

The area we studied is an area in the Southern area with four extraction sites. The extraction companies in this area have experienced many of the problems that affect all quarries on the island. Each of the quarries have come close to being shut down, and one quarry was forced to halt production for four months, and is currently experiencing restrictions on its production.

We studied this specific area because it is an area of rapidly increasing population and construction and provides a good example of the conflicts with residential development and natural resource protection. We analyzed several of the problems that might arise if the quarries in this area were to cease production. We interviewed representatives of two of the quarries in the area to learn about the problems they face, the markets they participate in, and their importance to the community. We analyzed what effects the closing of these quarries could have on the local aggregate market. This information can be used to illustrate the importance of the aggregate industry to the community and the need to keep the production facilities in operation.

Interviews

We interviewed representatives of two separate quarries that supply primarily to the southern region. We asked them questions about the obstacles affecting their ability

to operate, and the problems they are experiencing with the DRNA and residential development. We also inquired about the location of their market as well as the locations of the closest quarries that could also supply their markets, so that we could analyze the effect shutting down the quarries would have on aggregate prices.

Aggregate Producer Number One

The first representative we interviewed stated that the major obstacle to the operation of his quarry is the protected cave system located within the confines of the quarry. The DRNA has prohibited his company from blasting in the area surrounding the caves because of the effect the blasting would have on the cave system. Due to the restrictions the DRNA has placed on the extraction from the quarry, the production of aggregate has been significantly reduced. In certain instances, he has bought aggregate to make up for some of his loss of production. The purchase of this aggregate and the additional transportation costs has increased the price of the material that this company supplies.

His operation mainly supplies the Ponce region, and he has explained that the marble rock that he extracts is the best material available for concrete. This region is famous for its marble and such a high quality of limestone is not found elsewhere on the island. Therefore, the extraction of marble from these quarries is essential to the aggregate market. He also showed us the locations of the closest production facilities outside the area that may be able to supply his market in the event that his quarry was closed.

Aggregate Producer Number Two

The representative of the second quarry stated that the major obstacle affecting his ability to operate his quarry is residential development. In particular, a DRNA official lives near the quarry and therefore often intervenes in many of the operations. For example, in June of 1999 the production in the quarry was halted for four months, and has since been restricted to daily production at a fraction of the capacity. He stated that the DRNA listed ten reasons for closing the quarry, including problems with dust, traffic, insufficient signs, and disabled machinery. However, in the opinion of the representative, these reasons are not major violations and do not justify the closure of the quarry.

The representative explained how the speed and direction of the wind coming across the mountain has led to an increase in the amount of dust deposited in a nearby neighborhood. To remedy this problem, he has increased the use of water trucks and is in the process of increasing the number of banks and terraces of his quarry.

He also stated that when the quarry was established, there were no houses in the vicinity of the quarry. Housing has been increasing in the area and has not been a major problem until the past five or ten years. This company provides material to the Ponce region and the southern region of the island.

Specific Market Analysis

The four quarries, located in close proximity to one another, produce material that is essential to the aggregate market of Southern Puerto Rico. These quarries supply the construction materials throughout the southern half of the island, as well as certain projects within the San Juan area. In order to highlight the significance of these quarries

throughout the entire southern half of the island, we analyzed what might happen if these quarries were to be shut down.

Supply Of Aggregates

The four quarries supply the majority of the aggregate for the Ponce region, and are the only operations in the area that supply limestone material. If these four quarries were to be shut down due to residential complaints and problems, the price of aggregates in the area would increase, due to the increase in transportation costs.

Since these four quarries constitute the majority of aggregate production in the area, alternative locations to obtain aggregates, if the quarries were shut down, would be far away from the aggregate market of Ponce. The major alternative locations for aggregate would be to the west and to the north. The alternative to the west has five quarry operations but is located at least sixty kilometers away. The travel distance would actually be much longer due to the winding roads. According to the Ultima Tarifa Comision Servicio Publico, or the Public Service Tariff Commission, use of these alternatives would change the transportation cost of aggregates from $3.40 per ton to at least $8.65 per ton. The chart furnished by the Public Service Tariff Commission is shown in Table 4.25.

In the alternative to the north, only sand and gravel are produced. Limestone is not available from this location, which is the main material the area we studied supplies. This information suggests that construction costs will increase rapidly due to the high transportation costs imposed on distant operations.

Table 4.25 - Transportation Costs Of Stone And Sand Per Ton Per Mile

Ultima Tarifa Comision Servicio Publico - Aggregate materials - Stone and Sand Effective 12-01-95					
Distance (KM)	**Price ($)**	**Distance (KM)**	**Price ($)**	**Distance (KM)**	**Price ($)**
1	1.40	35	6.4	69	11.50
2	1.62	36	6.55	70	11.65
3	1.75	37	6.70	71	11.80
4	1.89	38	6.85	72	11.95
5	2.02	39	7.00	73	12.10
6	2.17	40	7.15	74	12.25
7	2.29	41	7.30	75	12.40
8	2.43	42	7.45	76	12.55
9	2.56	43	7.60	77	12.70
10	2.66	44	7.75	78	12.85
11	2.80	45	7.90	79	13.00
12	2.95	46	8.05	80	13.15
13	3.10	47	8.20	81	13.30
14	3.25	48	8.35	82	13.45
15	3.40	49	8.50	83	13.60
16	3.55	50	8.65	84	13.75
17	3.70	51	8.80	85	13.90
18	3.85	52	8.95	86	14.05
19	4.00	53	9.10	87	14.20
20	4.15	54	9.25	88	14.35
21	4.30	55	9.40	89	14.50
22	4.45	56	9.55	90	14.65
23	4.60	57	9.70	91	14.80
24	4.75	58	9.85	92	14.95
25	4.90	59	10.00	93	15.10
26	5.05	60	10.15	94	15.25
27	5.20	61	10.30	95	15.40
28	5.35	62	10.45	96	15.55
29	5.50	63	10.60	97	15.70
30	5.65	64	10.75	98	15.85
31	5.80	65	10.90	99	16.00
32	5.95	66	11.05	100	16.15
33	6.10	67	11.20		
34	6.25	68	11.35		

The demand for aggregates in the studied area will continue to increase through 2010. According to Table 4.21, this region will account for over 1.37 percent of the total population increase on the island from the year 2000 to 2010. In addition, the Ponce municipality will account for 2.83 percent of the entire population increase for the island. Between these two areas, the two major markets for the quarries, there will be an increase in population of approximately 4.1 percent. Because of this increase, the demand for aggregates in this region will account for approximately 4.1 percent of the entire demand for aggregates on the island. The projected demand for this area and the municipality of Ponce combined is 1,318,207 tons of aggregate, as illustrated in Table 4.21.

Similar to population, an increase in construction will result in an increase in the demand for aggregates. We analyzed the change in housing construction in this area from the year 1988 through 1999, and compared that to the change in housing construction for the island. These figures represent the number of new houses built in the region. We determined that this area represented 1.83 percent of the total increase of Puerto Rico in housing construction from the year 1988 through 1999. Based on this information, we concluded that with the projected increase in population, this number would continue to increase during the next ten years, which will result in an increase in the demand for aggregates.

Effects On The Local Economy

If the quarries in this region were to be shut down, it would have effects that reach beyond the construction industry. If these quarries stopped producing, the local construction costs would increase. As a result of this increase, construction activity

would decrease. This change would result in fewer homes for families in the area, as well as a reduction in the number of local jobs. Most quarries employ people from the local neighborhoods, and many feel that this practice is the best type of public relations available. If these quarries were to close, the local people employed in these companies would lose jobs and become unemployed. This low level of employment could hurt the economy as a whole as well as lower the quality of life. Many people in the area also rely on the aggregate companies to provide material for better homes and roads. If these quarries no longer operated in the area, this benefit to the surrounding communities would be lost.

Bayamón

Bayamón, as illustrated in Table 4.22, is projected to have the highest population increase with respect to the island. For this reason, Bayamón's quarries could some day have the same type of problems that some of the studied quarries are currently facing.

Population

Since the population projections from the year 2000 through the year 2010 indicate such a dramatic increase, it is likely that within the next ten years the housing developments surrounding the operations will move closer to the quarries. Since Bayamón is located so close to San Juan, the main market outside of the municipality of Bayamón is the San Juan area. If, as projected, the population increases by a large percentage, then the existence of quarries in Bayamón will be threatened.

If the quarries in Bayamón were to be shut down, the San Juan aggregate market would experience a decrease in the supply of aggregates, while the region would continue to grow rapidly and demand more aggregates.

CONCLUSIONS AND RECOMMENDATIONS

In this section, we take our data and analysis one step further in order to draw some conclusions about the problems of the aggregate industry as well as recommend ways to help alleviate these types of problems. We hope that these conclusions and recommendations will be useful to government agencies as well as the industry.

Conclusions

We drew the following conclusions based solely on data obtained using our methodology, and we strove to remain objective throughout the period of this project in order to help ensure that these conclusions and recommendations were in no way biased.

Interviews

The conclusions drawn from conducting interviews with members of the Board of Directors of AIPA, aggregate producers and government officials, are based on the opinions expressed through the survey and interview process.

Board Of Directors Of AIPA And Aggregate Producers

All the interviewed aggregate producers in AIPA, both members of the Board of Directors and producing members, have nearly the same opinions regarding the problems within the industry. We concluded from our interviews that the major problems in the aggregate industry are related to the methods utilized by government agencies in their permitting and planning decisions. Some of the specific problems, as producers see them, are the duration of the permit, the length of the permitting process, and the inefficient process of resolving problems.

The aggregate producers feel that the length of time for which a permit is issued is not sufficient. Because they need to reapply for a permit every three years, both they and the DRNA waste valuable time, money and resources. They feel that since the DRNA has the authority to intervene at any time when an operation is not complying with the regulations, the renewal process does not increase the ability of the DRNA to regulate and control operations. Therefore, in the opinions of the aggregate producers, permits should be issued for a longer amount of time.

The aggregate producers also believe that the length of time it takes for a permit to be reviewed and reissued is far too long. At this time, the producers must reapply ninety days before the actual expiration of the permit. This is a considerable amount of time when the permits are only issued for three years. Additionally, the current process for permit renewal can take six months to a year or more and producers can be forced to operate under automatic extension of the permit while the case is reviewed.

Aggregate producers also experience problems with environmental and residential conflicts. These types of problems often affect the ability to operate their facilities. On occasion, the DRNA halts the production while the conflict is studied and evaluated. The loss of production affects the supply of aggregates in the area.

DRNA

Through the interview with the DRNA representative, we have concluded that the DRNA is not currently reaching its goals and achieving its objectives. The DRNA frequently fails to maintain the correct balance between economic development and conservation and protection of the environment. We have concluded that these problems

may be due to the fact that it is understaffed, does not have a sufficient budget, and is not allocating resources in the most effective manner.

Total Production Of Aggregates

By analyzing the production estimates that we calculated and comparing them to the total possible capacity of the aggregate producers on the island, we concluded that the producers on the island are able to produce far more than they currently produce. In fact, the current rate of production is estimated to be approximately 50 percent of capacity. We determined capacity by totaling the maximum permitted amount of aggregate extraction per day. We determined the current production numbers by using cement sales and calculated the quantity of aggregate that was combined with cement to create concrete and then accounting for the aggregate in asphalt. This process can be seen in the Data, Results and Analysis section of this report.

If the producers began operating at full capacity, there would be a flood of supply within the aggregate market. Excess supply would drastically lower prices; as well as cut reserve lives down considerably. Since the majority of the producers are familiar with business practices and economics, they understand that producing at the level of which they are at now makes the most economical sense. They supply at the level that demand dictates, and they keep excess supply down.

Demand For Aggregates

Based on our regression analysis of past demand and our projection of future demand based on this analysis, we have concluded that in the year 2010, Puerto Rico will need an estimated 31,359,376 tons of aggregate. Comparing the demand with the current

maximum production capacity of 33,128,064 tons per year, we have concluded that the current producing facilities have the capacity to supply the demand for the year 2010. However, we calculated the demand of aggregates to increase by about five percent a year. Based on this estimate we have concluded that by the year 2012, the production capacity will not be sufficient to supply the demand. These calculations and conclusions are based on the assumption that the aggregate market will have the same trends as in the past and that government forecasts of economic growth in Puerto Rico will prove correct.

It is likely that in the next few years, new projects will be underway that will increase the supply of aggregates. The addition of more quarry operations to the island will increase the supply of these aggregates, and although these types of operations are expected, they cannot currently be accounted for in this project. In addition, if more construction projects occur in the future, than historically in the past, the numbers projected in this report will be rendered incorrect.

Aggregate Demand Per Municipality

By analyzing the population increase in each municipality relative to the entire island, we were able to conclude which municipalities on the island are going to have a large increase in construction activity. Municipalities in and around the San Juan region, such as Bayamón and Carolina, are expected to have a large increase in population, which we correlated to a large increase in construction activity. We concluded that areas with large construction activity would experience a large demand for aggregates.

In our analysis we divided the island into seven regions: Aguadilla, Arecibo, Guayama, Humacao, Mayagüez, Ponce, and San Juan. We have concluded that the region with the largest increase is the San Juan region. This region alone will account for

over twenty-five percent of the total population increase of the island by the year 2010. Bayamón, Toa Alta, Carolina, Toa Baja and Trujillo Alto are the five municipalities in the San Juan region that we concluded would have the highest demand for aggregates in that region.

We calculated the demand of aggregates per region for the year 2010 and compared the figure with the supply of aggregates per region. Based on these figures, we have concluded that the majority of the regions will be able to supply the demand for their region. However, the regions of Guayama and Mayagüez will have an insufficient supply for the projected demand.

These conclusions are based on our data analysis, which does not account for the possibility of suppliers located outside of the region contributing to the supply within a region. If an operation were located within close proximity of a region's boundary, it would be possible for this operation to supply both regions. Due to high transportation costs, if an operation were located far from a region's boundary, the likelihood of this operation being an economical supplier to another region is unlikely.

Recommendations

After drawing our conclusions, we have prepared a series of recommendations for the government agencies as well as for the producers of the industry. These recommendations could, in our opinion, improve upon the problems associated with the industry and the availability of material.

Aggregate Producers

We recommend that aggregate producers inform government agencies of the significance of the aggregate industry and increase the public awareness of the industry. The permitting and planning decisions of government agencies have a large effect on the state of the aggregate market. Increasing the recognition for the aggregate industry may result in more favorable permitting and planning decisions that benefit the industry.

Lobby The Government

Since government agencies base land-use decisions on the potential benefits to the public, we recommend that aggregate producers lobby the government to recognize the significance of the aggregate market and the benefits of the industry to the public. In particular, we recommend that aggregate producers utilize the DRNA and urge them to make recommendations to the Planning Board on behalf of the aggregate industry. We also advise aggregate producers to become more involved in municipal activities such as the Juntas de Comunidades (community boards). The Juntas de Comunidades serve as advisory boards to planning officials at the municipal level. Representatives from many industries serve on these boards, and it would be beneficial for aggregate producers to have representatives, especially in the municipalities with the highest projected demand for aggregates.

Aggregate producers must have data, such as the data included in this report, to present to government agencies in order to better demonstrate the industry's significance and needs. We recommend that the industry conduct supply-demand studies on an ongoing basis. Additionally, we recommend aggregate producers inform the agencies of areas where the data demonstrates a need for increased supply of aggregates. Informing

agencies would guarantee that the agencies making the decisions are aware of all the important information that should be reviewed prior to them making a decision, and would help them take this type of important information into account while making these decisions.

Increase Public Awareness

Additionally, aggregate producers should increase public awareness of the industry. According to the President of the Planning Board, the public hearing process is often the most influential in land-use decisions. Public relations projects should be continued and expanded upon. To increase awareness, we propose that the industry incorporate the media in their public relations projects in order to circulate positive press regarding the industry. The producers need to inform people in local communities about the benefits of a local quarry operation. They need to begin to show the positive effects that the quarry has on the local economy as well as the economy of the island. Before public hearings begin, the Planning Board usually distributes flyers that notify the residents of the possible opening of a quarry. We recommend that producers begin to distribute flyers of their own that highlight important benefits of the operation to the area. We also suggest that quarry operators take active roles in the community before the beginning of the public hearing process. It would be to the benefit of the producer to make first contact with local residents that will be affected by a new operation, and demonstrate concern for the neighborhood's well-being prior to the notification by the Planning Board of public hearings.

Preserve Surroundings

It is the industry's goal to extract as much material as needed, while having the least amount of adverse effects on the environment. With this in mind, we recommend that aggregate producers strive to protect their environment while increasing the public's knowledge of their efforts. It is the responsibility of the producer to minimize any damage done to the community and the environment by the operation. For example, producer's should help increase the safety around quarries by improving upon roads, and creating incentives for transporters to drive more safely and slowly. The operation should be active in community projects as well as responding to the concerns of the local residents.

We also recommend that the producers highlight their interest in protecting other environmental resources. In addition to the reclamation within their operations, producers should begin environmental projects outside of their operations, such as establishing nurseries and greenhouses. The DRNA and the general public could view these projects as exceeding expectations and law standards, and improving the public's impression of the aggregate industry.

Provide Buffer Zones

Aggregate producers can also minimize problems with the local communities by purchasing buffer zones to keep residential development a reasonable distance from the quarry operation. Although this might not be possible for current facilities, this recommendation should be considered for future quarry operations. They can also act as natural barriers to reduce the amount of dust that penetrates into the local development. It can also help to reduce noise pollution and improve the appearance of a quarry

operation. In addition to minimizing residential conflicts, the buffer zones can serve as land suitable for the environmental projects described above.

DRNA

We recommend that the DRNA establish clear goals and objectives and establish methods to achieve these objectives in order to maintain a balance between the extraction industry and the impacts of the environment in order to make decisions in the best interest of the island.

Develop Criteria For Evaluating Permits

We recommend that the DRNA develop criteria on which to base consistent recommendations and evaluations of a permit. Currently the DRNA grants permits based solely on the compliance with regulations. However, the availability of reserves is becoming increasingly limited due to environmental concerns and residential development. Therefore, in order to distribute permits more effectively and minimize environmental impacts, we advise the DRNA to base their criteria on factors such as demand in the area, size of the operation, the impacts on the environment, and the history of compliance of the company. By having such criteria, the DRNA could control the distribution of aggregates more efficiently and could analyze what permits are of higher priority than others.

Due to the rapidly increasing demand for aggregates and the limit of availability of reserves, it is essential that the DRNA base decisions on the aggregate market. Applications for permits in areas with high demand and low supply should be given preference. This practice would increase supply in areas with a high demand. If the

DRNA were to assess the market needs when issuing extraction permits, it would be possible to obtain an equal balance between supply and demand, and reduce the amount of shortages and excess supply.

Establish Methodology For Resolution of Problems

We also recommend the DRNA develop more effective methods of quickly resolving problems, such as conflicts with extraction operations and the communities or the environment. The current methods of evaluating permits and operations, and analyzing conflicts with residents and the environment require much time and personnel. Improving these methods would allow the DRNA to allocate their resources more efficiently.

An important step in improving the resolution of problems is to improve the record keeping. It is essential that the DRNA have accurate lists of currently operating facilities. We have discovered several operations that are not listed on the DRNA permit list as well and several inactive operations that are included on the list. We recommend the DRNA work closely with MSHA to continually update the list of operations. Additionally, we advise computerizing the records in order to decrease paperwork as well as time and personnel.

In order to more quickly resolve problems with environmental concerns, we recommend the DRNA conduct studies on the effects of blasting on areas such as cave systems and endangered species. Production on the island has been greatly reduced due to the DRNA protection of these areas. Analyzing and studying these effects would allow the DRNA to set standards that would permit aggregate producers to extract as much as possible while still preserving the environment. We recommend the DRNA

conduct these studies to better guarantee that the current regulations are neither excessive nor insufficient.

We also recommend that the DRNA and legislature extend the duration of permits. Based on our interviews, we have concluded that the investment in quarry operations is quite large, and a longer permit would help aggregate producers ensure that they will be able to fund their operations and thus have more money to make the necessary changes to better comply with regulations. In addition, increasing the duration of permits would decrease the amount of money and paperwork for both the DRNA and aggregate producers. This change would allow them to allocate their scarce resources more effectively.

Planning Board

It is the job of the Planning Board to determine the best use of the land. For this reason, it is important that the aggregate industry work together with the Planning Board in order to ensure that the concerns of aggregate producers are considered in land use decisions.

Establish Methods For Submitting Recommendations

Since the Planning Board depends upon the comments and recommendations from government agencies to make land-use decisions, we recommend the DRNA and Planning Board establish a methodology for submitting such recommendations. We suggest that the Planning Board and the DRNA consider a standard recommendation document that includes the recommendation, the criteria the DRNA used for the decision,

and a list of the positive and negative impacts the proposed use of land will have on the environment, the economy, the local community, and the general island population.

Work Closely With Local Planners

As the trend toward the transfer of the planning process from the central level to the municipal level continues, it becomes important for the Central Planning Board to work closely with the local planners to ensure the long-term benefits to the island are considered as well as the benefits to the individual municipalities. Some uses of the land, such as a quarry operation, might not be desirable on the local level but are essential for the development of the island. We suggest the Planning Board continue their cooperation with local planners to ensure that necessary uses of the land can be developed. Additionally we advise the Planning Board to consult aggregate producers and the DRNA to determine the municipalities and regions where a quarry operation will be most beneficial, locally and island-wide.

Develop Methods To Increase The Supply Of Aggregate

Based on the previous conclusions, we recommend that the DRNA and the aggregate producers begin to plan for the possibility of a limited supply of aggregates. We recommend that they consider ways to increase the supply of aggregates. To increase the supply we have determined a few possible options.

Increase Daily Extraction Limit

The first option to increase supply is to increase the daily extraction limits set forth by the DRNA permit. Increasing the extraction limit could increase total productivity, and therefore increase the supply of aggregates. This option, however,

would lead to a shorter life of the quarry and may not be possible with the existing equipment and available technology.

Permit New Quarry Locations

Another option that exists is to permit new quarry locations. In order to make this a viable option, we recommend that the DRNA and the Planning Board begin to plan for the protection of valuable reserves. To insure that lands will be available for expansion of production facilities, the planning agencies must consider the reserves when allocating areas for residential development. In addition, we recommend that studies be conducted on the locations of valuable reserves and that the aggregate producing industry informs the planning agencies of such reserves, so that those areas can be kept free from development.

Consider The Importation Of Aggregates

The possibility does exist for the importation of aggregates, however many problems could arise from this alternative method of supplying aggregates. First, it would be difficult to regulate the quality of the imported aggregates, which could lead to lower quality concrete.

Importation of aggregate would increase the price due to increased transportation costs, which would in turn increase construction costs. When the supply of aggregate is low enough to cause local aggregate prices to match the price of imports, importation becomes a viable source of aggregate. Since the transportation costs are quite high, the demand on the market would need to exceed the supply so much that it would lead the costs that match importation. For this reason, the government should not allow importation of aggregates until the market requires it.

If any aggregate is to be imported, it is vital that the government plan accordingly. The government needs to decide which agencies have jurisdiction over the importation of aggregates. This agency must determine and set laws that regulate the amount of importation as well as the quality of imported materials. The agency must maintain a steady market and not allow too much aggregate to be imported, thus creating an excess supply. Conversely, the agency must permit enough aggregate to be imported to meet the demand and keep prices as low as possible.

Study Offshore Sand Deposits

In addition, offshore deposit extraction could be considered as a possible source of sand. We are aware of numerous studies furnished by the DRNA that analyzes offshore sand deposits, mainly Escollo de Arenas off Vieques, Isabel off the coast of Isabel, and Bahía Sucia off the coast of Cabo Rojo. We recommend that the DRNA review all the studies that have been conducted and determine what concerns still exist that were not addressed or fully answered in the previous studies. We suggest that the DRNA then conduct studies that would answer all the questions relating to the environmental impact of extraction from these areas. From all the previous studies, the DRNA should then determine whether to begin to issue permits for offshore sand extraction.

It is the view of a producer that before the first permit is issued, the DRNA should develop a plan to regulate all aspects of offshore sand extraction. First, they should determine a way to guarantee competition among permit applicants, to ensure open competition and to avoid a monopolistic offshore market. The DRNA should develop guidelines to maintain fair costs. For example, the DRNA needs to make certain that the

price of offshore sand costs approximately the same price as sand extracted or produced from onshore. They could accomplish this by setting costs of offshore sand so that it is competitive with onshore prices. Whether this process would involve the DRNA creating incentives to extract offshore or creating obstacles, such as royalties to increase the price, sand obtained from both onshore and offshore sources should be comparable in price.

The DRNA should also regulate the quality of sand that is extracted from these offshore deposits. This regulation might include required desalinization of the sand, among other processes.

We recommend that the DRNA accomplish all of the above before distributing permits for these deposits. Once all these processes are finalized and organized, we suggest that the DRNA begin to issue permits for the extraction of sand from offshore deposits, when the market dictates, as it could be in the best interests of the island.

Future Studies

As mentioned earlier, we recommend that aggregate producers, with the cooperation of government agencies, conduct studies similar to this one on an on-going basis. Although the results of our study are detailed and accurate, we feel that there could be some improvements to our study. Since our time was limited, we were unable to analyze information at the depth that would yield the best results. For this reason, we have developed some recommendations that could prove useful for AIPA and the aggregate industry.

In addition to our research, we believe that, with more time, it would be beneficial to construct a complete supply-demand model of the aggregate industry. The model

should include a distribution of aggregate consumption into public and private sectors and into industrial, commercial, and residential sectors. The public sector includes government expenditures such as roads and highways, and the private sector includes houses. An analysis of the separate sectors might yield different correlations and results that are more accurate. For example, the industrial and commercial construction would be more dependent on rate of economic growth and the cost of business borrowing. The housing sector would be more dependent upon such variables as income per capita, population and mortgage rates. Therefore, the regression analysis and forecast would include different variables than those used in our study.

In addition, we would recommend to someone continuing this study, that they break both the supply and consumption of aggregates down to the regional level. In order to perform this task, transportation costs would need to be analyzed more thoroughly, as well as the exact location and market of the quarry operations on the island. This information would more accurately allocate the supply of aggregates to each region.

We recommend developing a process to better estimate the demand of aggregate per region. We suggest, if possible, acquiring independent economic variables, particularly GDP, defined by region, and inserting these variables into the regression analysis to project future demand per region. After determining the supply and demand per region, we recommend analyzing the data and comparing supply to demand to determine regions with insufficient supply of construction aggregates.

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Appendix A: Asociación de Industrias Productoras de Agregados

The Asociación de Industrias Productoras de Agregados (AIPA) is a non-profit organization that represents many of the aggregate producing companies on the island of Puerto Rico. The main goal of AIPA is to give the aggregate-producing industries of Puerto Rico a common voice in local government. Founded more than thirty years ago, AIPA has shown a strong commitment from its members, which has made it a widely respected organization, by both government officials as well as the industry as a whole.

Although AIPA is a non-profit organization, it has an annual operating budget of $25,000 to $30,000. The association conducts its operations out of the offices of the ten members on the Board of Directors. This Board has ten members, nine annually elected members and the president from the previous year who is automatically on the Board.

- Luis E. Terrassa of Empresas Terrassa: President
- Benjamín Román of Puerto Rican Cement Corp.: Secretary
- Rey Cordero of Pérez Quarry: Vice President
- Ricardo Venegas of Sanson Corp.: Treasurer
- Carlos E. Robles of Con-Aggregates Supplies: Associate Member Rep.
- Carlos Ortiz Brunet of San Antonio Quarry: Board Member
- Carlos Monserrate of Hormigonera Mayaguezana: Board Member
- Dan Johnson of Master Aggregates: Board Member
- Angel Rovira of San Juan Cement Corp.: Board Member
- Melba Figueroa of Productora de Agregados: Former President

In addition to the ten companies that these elected members represent, eighteen additional producing companies make up the association. The twenty-eight producers collectively have forty-five of the estimated one hundred plants throughout the island. The forty-five plants represent approximately 70 percent of the total aggregate production in Puerto Rico.

In addition to the twenty-eight producing members of AIPA, there are an additional fifteen associate members. These members represent many of the larger companies that benefit from aggregates and the aggregate industry. These types of companies include asphalt producers, cement producers and construction companies. Since these companies rely heavily on aggregates in their own industry, they have a strong interest in the aggregate industry and thus AIPA.

The members of AIPA do some lobbying in the fact that they are always in contact with government officials in order to advance the interests of their industry. Although some lobbying occurs, it does not include monetary contributions to individuals in political positions.

AIPA currently wishes to obtain information about the adequacy of the supply of aggregates to meet market demand now and in the future. The main objective of this study is to aid in the defining of policy proposals as well as in the analyzing of AIPA's future goals and strategies. This information can help to improve the permit process of aggregate extraction, which is currently inadequate. In addition, the results of this study would help to guarantee that aggregate deposits are considered before other permits, such as residential or commercial, are awarded. This information will aid in increasing the efficient extraction of aggregates in Puerto Rico.

Appendix B: Interview With Board Of Directors Of AIPA

To maintain company confidentiality, the following questions are numbered but not labeled. This way, the answers are not labeled by who responded.

1. **When was the company established?**
   - i) The company was established 25 years ago (1975).
   - ii) The company was established 35 years ago (1965).
   - iii) The company was established 45 years ago (1955).
   - iv) The company was established 45 years ago (1955).
   - v) The company was established 45 years ago (1955).

2. **Has the company expanded since its inception?**
   - a. **When?**
   - b. **By how much have the reserves increased?**
   - c. **How much has production increased?**
     - i) The company started with 1 plant; 12 years ago we had 2 plants; 3 years ago we had 3 plants; 2 years ago we had 4 plants; and this year we will have 5 plants. We closed one down, so we will really only have 4. (Production and reserve data will be covered by the spreadsheet).
     - ii) The company first expanded in 1972. In total, our reserves have decreased, while production has increased by approximately 200 percent.
     - iii) The company started with one plant, but now we have 19 concrete batch plants. I have no idea about reserves and production, although I know production has increased.
     - iv) More than doubled in 15 years. In the last 10 years, there hasn't been very much increase. In 1972 the oldest current operation that we have began. The ones that we had from 1955 are not in existence now.
     - v) Yes because we began... We needed aggregates so we started extracting in the 1960s.

3. **How many different plants does your company operate?**
   - i) We operate 4 plants currently.
   - ii) The company operates 4 separate plants on one permit on one site of land, all using the same materials.
   - iii) 19 concrete batch plants. We have 2 extraction sites as well.
   - iv) We operate 4 plants with 5 permits.
   - v) We operate 2 plants.

4. **Are you in the process of applying for new permits?**
    a. **How many?**
    b. **What types of problems are you currently facing that might inhibit the process?**
        i) We are not applying for new permits, we've received a new one recently, but the plant is not online yet. No serious problems.
        ii) We are not currently in the process to obtain new permits. The main problem is that available/permittable sites are quite scarce. I tried to get a permit in a town, but the government would not allow it, they said that it would be too expensive for me to extract. I think there are politics involved. I think they want me to give the land to the government for low-income housing. The House of Representatives as well as the mayor were against my attempt to attain a permit. They said that there were environmental areas, rivers in adjacent areas. It was a high-erosion area. They recommend that we don't use the land for anything.
        iii) No. We have 19 sites, and buy the majority of our aggregates from other companies. We currently see no need to expand our aggregate operations.
        iv) We are reapplying for permits. Currently we are not looking for new permits in new locations.
        v) We are looking for more sites, but we are not yet looking for new permits. We're exploring.

5. **How close are any of your current facilities located to residential areas?**
    a. **Are there any complaints about your quarry operations?**
        i) There are residential areas all around us. We've had problems with one woman who lives over a quarter mile away. She claims her and her kids have asthma and that the plaster fell from the ceiling due to our operation. She also says that dust is a large problem, so we supplied them with air filters, and she demands that we supply a cleaning woman to come to the house everyday and clean. There are numerous houses in between hers and our operation; no one else has any problems.
        ii) We are within 500 feet of residential areas, although residential areas are zoned a bit closer. We have no problems with residents in the area, we've never had any complaints.

iii) When we started this plant had nothing around, and now as you can see, the town has grown around us. We have no real problems other than people complaining about dumping.

iv) One of our plants is close to residential areas. One of our other plants they are trying to build residential houses right in front of the plant. One specific person constantly complains, but other than that we don't have any real big problems with the neighbors.

v) Yes. If we buy land now, we have to buy more to act as buffer zones. In some places, the neighbors were here first, so we have to do some public relations work. Residents complain, definitely. We've gotten complaints that dust is drying up the neighbors' plants. In fact, that particular dust is used as a fertilizer.

6. **Are any of your current facilities located near any "environmentally important" areas, such as caves or water supplies?**
   a. **Are these types of areas delaying your operations?**

i) Everything is close to a water table. Since we're not allowed to mine to the water tables, it doesn't matter. Storm water is a problem. Since quarries are on hills, when storm water runs off, it mixes with process water and thus becomes contaminated. We have to treat it all as process water.

ii) We are located near environmentally important areas but they do not hinder our operations.

iii) Not really.

iv) The limestone quarries are right next to reserved areas for caves. It doesn't impede our operations. We have to stay 25 meters away from rivers and other bodies of water. The caves don't matter to us anyway because they are holes and have nothing in them.

v) One operation is located close to a very important body of water. There are caves on the other side. We have endangered species. We've spent... taking care of plants, selecting and reserving land to keep plants alive, and building temperature and humidity controlled greenhouses. It's a big cost.

7. **Are environmental/residential types of problems becoming more of a problem than the past?**

i) Definitely. Everyone likes to rail against the big guys. Since the island is becoming more populous and

income levels are rising, the public is becoming more informed about environmental concerns.

ii) Yes.

iii) The island has run out of dunes, so we couldn't extract sand anymore. Some salt content in the dune sands, but below regulations. Land is scarce, more expensive, and more difficult to purchase. We can only work certain hours because of the residential housing in the area. Before they were around, we could work 24 hours a day if we wanted to. The production time is different for every plant. The time depends on the area surrounding the plant.

iv) Yes because there is a lack of scientific analysis as well as a lack of personnel. When a concern is raised they take the easy solution. There are a lot of uninformed claims against the operation.

v) We've had to hire experts to prepare studies. We have to hire cave experts. The bat droppings are dangerous. The environmental conscience of the public is growing.

8. **Do you have specific company regulations to control air, dust and noise pollution?**
   a. **Are they enforced?**
   b. **Are they effective?**

i) Of course we do. We are only allowed to operate during certain hours to keep down the noise, and we can't work on weekends. [Confidential]

ii) Yes, yes and yes. We have some trouble with rainwater, since we must contain it.

iii) Permit regulations are strict, we have to hire people to do it. There is a lot of debris, we need a lot of area to operate. We need places to dump, storage, etc.

iv) We have air quality permits and estimate the volume of dust created by our operations. We follow EPA guidelines. If you don't comply, they can fine you. The costs are getting stiffer.

v) We exceed the EPA regulations. We've [Confidential]

9. **Does your company exploit each quarry to its fullest potential?**
   a. **Do laws keep your company from doing this?**
   b. **Does anything else impede this process?**

i) We try to. Laws really don't. Nothing really impedes our process.

ii) Yes we exploit to our fullest potential, we are not impeded.
iii) No. It would increase the production in the market.
iv) Not applicable.
v) We exploit everything to their fullest potential. We are more efficient that way.

10. Does your company ever extract a site at a rate close to, or at, the limit set fourth by the site's permit?

i) Depends on what your definition of extraction is. [Confidential]
ii) When we report a permit, we get a limit higher than that of what we need. That way, we play it safe.
iii) No, if we had permits, we'd go a bit high to make sure we are within the limit. There is no limit on concrete production.
iv) We set the permitted daily amount is higher than what we can produce at full capacity, just to be safe. We have a permit to increase capacity.
v) We extract at what the permit says. At any time they can check up on us. The DRNA has aerial photographs and they can tell home much we have extracted. It doesn't mean that we need to do that much each day, but by the end of the year we should have that amount.

11. What do you feel are the biggest obstacles facing the aggregate/extraction industry?

a. Why do you feel they are such a problem?
b. How would you go about improving them?

i) Public relations. We try to improve it, the NSA tries, but no one likes the aggregate producers. The government isn't the problem; they're a go-between for the public and us. Open houses; food, refreshments, technical experts, and bands.
ii) Permits are the real concern of the industry. The environmental quality board gives two permits; a construction permit and a processing (operating) permit. They give the construction permit and you are allowed to build, then the neighbors say something and they oppose it so that then they won't give you the operation permit, although you've already made the

investment and equipment and such. I've been trying to expand and buy deposits for the future during the last 5 years but there are residential areas all around. Once you give a permit that should be it; it should be understood that they will give the operation permit. The purpose of the permit that all things are done correctly, it should be based only on if you comply with the standards that should be enough. The DRNA bylaws say that they can stop me anytime for any reason.

iii) Permits in aggregate industry seem difficult to find. Aggregates are scarcer than demand. We have to make do with aggregates that aren't as good now as they were in the past- that's ok though.

iv) Excessive regulation. Regulation does not apply equally to everyone. Simplify regulation and extend the permit length. We need to ask the banks to give us a 15-year loan and they see that the permit is not that long. It is hard to make long-term investments when you only have a permit for 3 years.

v) There is no difference between a bona fide producer and a developer. You need to prohibit developers from getting permits to extract. These guys don't have to comply with anything, they don't care about the air, dust and people's health. They are giving the industry a bad name. They shouldn't have to take down a hill to build a house. In California, they build beautiful houses on hills, why can't they do that here.

12. What types of public relation projects, if any, is your company involved in?

a. Why does your company take part in these projects?

b. What does your company hope to gain from these projects?

c. How does your company choose the projects they take part it?

i) We do stuff for schools and churches and for the whole community. It's hard to get mad at the company that is helping out the community so much.

ii) None.

iii) None, I don't see a problem with public relations. We haven't had any public relation problems.

iv) It can be very expensive. Our biggest public relations force is our employees. They come from the communities we are located in. We do public relations with government agencies, but not with the public. We do some small community projects.

v) We offer different organizations, such as girl scouts and schools, seminars to talk about preserving the environment and why it's a good opportunity to be a miner. We supply money to schools to children with good grades. We supply communities with water when the government doesn't supply it, especially following hurricanes. We open rivers that have gone off path. We clean the roads removing fallen trees. We are members of organizations that protect the environment. We are always available for seminars. I am a public figure. I can't go and hide. I am a representative of the industry. We sponsor a festival every year, like "Christmas in July". I appear in legislature to defend the industry.

13. In your opinion, are there drawbacks in the permitting process?

a. What are they and how do you think they could be resolved?

i) It takes a lot of time and money. [Confidential]

ii) They ask too many things for us to comply with. We've asked them to make it shorter and they did, but then they added more things. The people giving away the permits are not qualified to do that job. For example, they are giving permits for explosives, and they have no idea about explosives. There's no use for all those warnings. There are supposed to come around every 3-4 months to make sure we are doing everything right, but they only come if someone complains and the press gets on their back. It takes years of studies to shut the place down, but you're production has to stop the whole time. They are not identifying where resources are to be able to identify where to give permits. A woman from the DRNA once told us that if you have a natural resource you can't get to then you have no resource at all.

iii) Permits are a problem in the concrete industry as well. It's easier to get a construction permit than an extraction permit. Laws are not a real problem.

iv) The agencies don't give recognition to the industry. They don't realize that the industry is essential for development, construction depends on the industry.

v) The government can't fulfill the supervising of the industry. They have a lack of budget. Every year it becomes more difficult to extract. Reserves will be

limited in the future. Permits should be for the life of the deposit, because they can shut us down any time we're not complying. If we've been complying, we should get the permit. They should not give extraction permits to developers. They are not using planning instruments as they should. We shouldn't allow sand extraction. We want to develop tourism, where are they going to play?

14. Do you feel that the DRNA uses acceptable criteria to determine what extraction permits they issue?

a. What do you think they should change?

b. Of the criteria, which should be given the most consideration?

i) They do fine.

ii) The environmental assessments are not difficult to do. Before 1978 there was no DRNA, so people could do anything they want before that.

iii) DRNA plays an important role because they own the rivers.

iv) It's really just a political-liability checklist.

v) The Department should have a clear vision of what they want to protect. There has to be a true plan of what is going to happen in the future.

15. How does the aggregate industry affect or benefit the local community?

a. Environment?

b. Economy?

c. The economy of the entire island?

i) Grass and trees are greener around a quarry because the soil is remineralized. We provide jobs just like any other industry. We help out with schools, churches, etc. Construction and housing costs go down. We help make better roads and better access.

ii) Not asked.

iii) They supply concrete for buildings. Growth depends on concrete.

iv) Jobs, construction material, if you don't have aggregates, you don't have concrete or cement.

v) The industry makes better use of the natural resources on the island by responsible extraction. Aggregates are needed for building concrete housing. Everyone should

have a concrete house. Aggregates are used for agricultural uses, they are used to nourish the earth. Limestone dust is a fertilizer. Aggregates are an additive in hamburgers and are a filler in toothpaste.

16. Should larger operations be given permits ahead of smaller operations (therefore making quarry sites more efficient)?

a. Do small operations hurt the industry as a whole?

i. How?

i) It's hard to discriminate on the bases of size. Larger operations are more efficient. [Confidential]

ii) Not asked.

iii) Not applicable for this interviewee.

iv) Everyone has the right to be considered. Size shouldn't be the only criteria, experience should count.

v) The question should be about large and small, it should be a question about more experience. If you have a proven record of compliance, you should be considered. It takes a lot of money to comply with the law, it's too expensive to operate for the smaller companies. Small numbers just don't work because if a small quarry starts then there will be 3 residential developments surrounding it.

17. Once you are finished exploiting your quarries, what will you do with them?

a. Will they become available for residential or commercial development?

b. Does your company do any type of reclamation?

i) One plant will be zoned commercial, one industrial, one will be a flood plain, and one will be a landfill.

ii) That's nuts. Once you cut down a mountain, you can't put one back in. We're going to zone it all industrial because there aren't many industrial zoned areas. I'm paying to restore the land every year when if I were to reclaim the land I'd only pay the last year.

iii) It's going to be zoned for industrial. If it's not industrial, you can go to the government and have it changed to industrial. When you go to have it changed, you have to go through public hearings and things like this.

iv) Develop it industrial. We have a planting program on an ongoing basis.

v) It depends. It's hard to look into the future. If the demand for land is for industrial things, we will do that. Investors will decide that. Only time will tell. We do a lot of reclamation. We have an ongoing reforestation program.

18. Do you feel that economic growth affects the aggregate industry?

a. How?

b. What else affects the aggregate industry?

i) Yes. When interest rates go down, everyone starts investing; they build new hospitals and homes. Prices were higher 3 years ago because of a spike in the construction industry, and a quick shortage of reserves. Government investment drives construction, for example Chapter 936. Most people don't report their production because USGS forms are distributed only in English, and there is no incentive to give the correct information anyway.

ii) We have to have a balance between economic growth and the beauty of the island. They have a point of view it's good to keep good things of some places but you must give and take.

iii) Not asked

iv) The construction sector of the economy is a stable source of employment. Infrastructure is essential for growth.

v) Not asked.

Appendix C: Interview With DRNA Representative

1. **What steps are necessary to acquire an extraction permit?**
   a. You request a permit from the DRNA. You have to provide information about location through a topographical map. Depending on the type of extraction and the area, an environmental impact statement may be necessary.

2. **How long does it usually take to get a permit?**
   a. It takes 2-3 weeks to submit a request including the location. 6 months to a year to look at the permit. If there are environmental impact statements, supposedly 3 months, but it takes a year.

3. **Which step takes the most time in the permitting process?**
   a. The environmental impact statements.

4. **Is there anything that might speed up the process?**
   a. Hire more people.

5. **How long does the permit last?**
   a. 1 to 3 year permits. Most are 3 year permits.

6. **Why does the permit last for only this amount of time?**
   a. To add more control to the process. Often, this is the only time they actually assess the operation, since they aren't going out into the field. No, they do not make money off the process. The little money that is supposed to come in from permits now goes elsewhere. The only way to get money is from government owned land with operations because then they get a royalty.

7. **We've spoken with many aggregate producers, and they feel that permits should be given for the life of the operation, what reasons would you tell them that this is a bad idea?**
   a. I would recommend longer than 3 years. When mining leases could be for 20 or 30 years, a 3 year permit doesn't make sense. When I was Secretary, I suggested

8. **When a company reapplies for a permit, for what reasons would you deny the permit?**
   a. If something has changed on the permit.

9. **Are there guidelines for how many permits you issue for a region?**
   a. No problem issuing permits together, especially in the past many quarries were close together. Now they don't like to work close together as much.

10. **Are there guidelines for how many permits you issue a year?**
    a. No.

11. **Does every company that applies for a permit receive equal consideration?**
    a. They are supposed to look at the history of compliance. Whether they do or not depends on a lot of things. They go into detail when there is a public outcry. Environmental groups and resident complaints get attention.

12. **Do you consider the demand for aggregate in a specific area when deciding to grant a permit?**
    a. No.

13. **Is the Department aware of the locations of valuable aggregate deposits?**
    a. No, they don't look at that.

14. **If they were aware, would it have any affect on permit decisions?**
    a. I don't think so, they don't look at that.

15. **Is there a distance required between an extraction site and residential development?**
    a. No. they recommend to the Planning Board to not zone residential next to quarry operations. The Planning Board doesn't always comply due to political pressures from other people.

16. **When a permit is pending, do you make the community aware that a company wants to extract near their homes?**
    a. Yes, they publish in 2 news papers. People don't always see them. They can do petitions and public hearings.

17. **Is there a difference between the extraction permits for an aggregate producing company and a construction company or developer?**
    a. Many think that it is the responsibility of the DRNA to regulate construction, but is actually the Planning Board and ARPE. If the Planning Board and ARPE give a construction permit, they are exempt from a DRNA permit except if they take material out of the property and sell it.

18. **Do you make sure that developers are complying with all regulations when they extract?**
    a. It is not our responsibility. It is ARPE.

Appendix D: Interview with President of the Planning Board

1. **What is the purpose of the Planning Board?**
    i. The purpose of the Planning Board is to guide the social, physical and economic development of the island, and in doing so, to provide a better quality of life for the Puerto Rican people.

2. **Is it true that companies have to obtain a use permit after obtaining an extraction permit from the DRNA?**
    a. **What is the process of doing this?**
        i. Yes, if a processing permit is a type of land use permit. Submit a land consulting permit to the Planning Board. We review the environmental impact statement and ask all agencies for their comments with respect to the permit. We adopt it as our own and submit the impact statement to the EQB. Then the whole process goes to the public hearings. After the hearing, the lawyer makes a report based on the hearing. We wait for the company or the operation to comply with Law Number Nine.

3. **Does every company that applies for a permit receive equal consideration?**
    i. Yes.

4. **How does the Planning Board determine what the best use of the land is?**
    i. By referring to the land use plans. The economy governs what the best use is. It changes when the economy changes. Commercial zoning has just about reached its peak, and now there is a lot of demand for residential housing projects. It depends on the project. We have to look at the short-term and long-term benefits of the project to see what is best for the quality of life for the people.

5. **When deciding the best use of land, does the planning board look only at the short-term benefits or do they look at the long-term aspects as well?**
    i. See previous question.

6. **Does the Planning Board consider aggregate reserve locations when they zone areas?**
    i. No we can't do that. It is the job of the DRNA to recommend areas to protect. We rely on agencies that are specified to do this type of study.

7. **Once all the power is distributed to the individual municipalities, will this planning board have the authority to overrule decisions made by municipalities?**
    a. **How would the planning board handle a situation in which none of the municipalities want to have, or plan for, a quarry?**
    b. **Also, what would happen if the best use of land would not be in the interest of the area it is located in, but is in the best interest of the entire island?**
        i. We have the final say, we have the power to overrule. If the quarry were in the best interest of the island, we would overrule the decision of the municipality. The municipalities generally agree with the decision of the Planning Board, but sometimes there are conflicts and if they wish to contest our decision, they can always take it to the courts, and the court ruling is final.

8. **We've heard of mine zoning areas, but don't understand what this type of zoning entails, could you explain?**
    a. **Why isn't this type of zoning used more often?**
        i. We use high level industrial, industrial-2 for quarries. We've never really used the mining zone. 10 % of this high industrial can be used for commercial, but no residential can be on it. We try to do buffer zoning for some projects. We never put high industrial next to high residential. We try to place a low industrial area in between.

9. **Does the Planning Board have any criteria that specifies how far from a quarry residential zoning can be applied?**
        i. Not really. Zones are placed right next to one another.

10. **To what extent does the planning board work with agencies such as the DRNA to determine the best use of land?**
        i. We depend on them for recommendations. They are the environment specialists. We work closely with them.

11. **We've been told that the DRNA makes suggestions to the planning board regarding zoning around quarries, is this true?**
    a. **What type of recommendations do they make?**
        i. I've never heard of that. If they had recommended this, we would consider it.

Appendix E: Bylaws To Regulate The Extraction Of Materials

These bylaws were adapted from the document entitled *Bylaws To Regulate The Extraction Of Materials From The Earth's Crust.* There have been minor adjustments to English grammar in order to improve the ease of reading.

ARTICLE 1 – LEGAL BASIS

The secretary of Natural Resources under the authority conferred to him by Article XIX of Law No. 144 of June 3, 1976, adopts the present bylaws in order to regulate the granting of permits for the extraction, excavation, removing and dredging of the components of the Earth's crust known as sand, gravel, stone, earth, silica, calcite, clay and any other similar component of the Earth's crust, that is not regulated as an economic mineral, in public and private lands, within the geographical boundaries of the Commonwealth of Puerto Rico.

ARTICLE 2 – DEFINITIONS

Section 2.1 – Components of the Earth's Crust

Any material in a compact or loose state that is not regulated as an economic mineral. It includes but is not limited to: gravel, sand, stone, earth, silica, calcite, clay and any other similar component of the Earth's crust in public and private lands.

Section 2.2 – Department of Natural Resources

The Department of Natural Resources of the Commonwealth of Puerto Rico, hereinafter referred to as the Department.

Section 2.3 – Secretary of the Department of Natural Resources

The Secretary of the Department of Natural Resources, hereinafter referred to as the Secretary.

Section 2.4 – Permit

Written authorization by the Secretary of the Department of Natural Resources, to any person, natural or juridical or group of persons, department, agency, quasi-public corporation, Municipality or instrumentality of the Commonwealth of Puerto Rico, to make excavations, removal and/or dredgings of the components of the Earth's crust, in public or private lands within the geographical boundaries of the Commonwealth of Puerto Rico.

Section 2.5 – Petitioner

Any person, natural or juridical, association or group of persons, department, agency, quasi-public corporation, Municipality or instrumentality of the Commonwealth of Puerto Rico, that requests a permit.

Section 2.6 – Concessionary

Any person, natural or juridical, association or group of persons, department, agency, quasi-public corporation, Municipality or instrumentality of the Commonwealth of Puerto Rico, to which a permit is granted.

Section 2.7 – Law

Law No. 144 of June 3, 1976 hereinafter referred to as the Law.

Section 2.8 – Renewal of Permit

The renewal of a permit will signify the application for the renewal of a previous permit, granted to the same petitioner, to carry out the same operation that he did carry out in the previous period for which he was granted a permit of extraction, in the same place and under the same circumstances.

Section 2.9 – Incidental Operations

Incidental operations covered by the present bylaws, shall be considered, those works of excavation, extraction, removal and/or dredging of the Earth's crust, whenever said excavations or removals be incidental to/or necessary for works whose construction have been authorized to be carried out at the same site of the extraction, removal, extraction or dredging according to legal dispositions. Likewise, they shall be considered incidental operations those in which an authorized permit is granted to extract quantities less than two-hundred (200) cubic meters per permit granted.

ARTICLE 3 – ON THE APPLICATION FOR/AND GRANTING OF PERMITS

Section 3.1 – Any person, natural or juridical association or group of persons, department, agency, quasi-public corporation, Municipality or instrumentality of the Commonwealth of Puerto Rico, that wishes to perform any activity related to the extraction, excavation, removal or dredging of the components of the Earth's crust, within the geographical boundaries of the Commonwealth of Puerto Rico, shall, provided the previous deposit of the sum of two-hundred and fifty dollars ($250.00) in a certified check or a postal money order issued in the name of the Secretary of Finance of the Commonwealth of Puerto Rico, apply for a permit in FORM DRN, to be filed at the Department, submitting the original and four copies.

Section 3.2 – Any petition through which the granting of a new permit or the renewal of the one in force is requested, shall be addressed to the Secretary of the

Department of Natural Resources, and the same shall be duly sworn to by the petitioner, his attorney or legal representative, and shall contain as part thereof, the following information:

Name and postal and residential address of the petitioner. In case of a corporation, name and postal address of each one and all of its directors and shareholders. Besides, it shall also be included, a certification of being in force, issued by the Secretary of State, relative to the existence of said corporation. In case of a civil partnership the name and postal address of each one and of its partners. Besides, it shall be included a certified copy of the public deed by which said civil partnership was formed. In case that all or some of said documents be on file in the Department, they, then, be incorporated by reference to the petition, recording thereon, that these documents have not been substituted or amended.

A detailed exposition of the facts whereby the petitioner trusts to prove that granting him the permit applied for, the same will supply an economic, industrial or any other kind of need, provided said operator will not impair the comfort, the convenience or the security of the public. In case of renewals only any change occurred shall be expressed if the exposition has been previously submitted.

Quality and type of material to be extracted.

Exact location of the area where the extraction of material is projected, expressed by means of a map or plan on a scale not less than 1:20,000. In case of renewals it is not necessary if it has been previously submitted.

Dimensions and location of the area to be excavated indicating the inclination of the slopes around the excavation and the depth of the same.

In case of coastal water, a marine chart of the area shall be included, indicating the maritime-terrestrial boundary, the elevations of the submerged land, the configuration of the adjacent coasts, localization of reefs, direction of the maritime currents, neighboring coastal structures, navigation ways and port facilities.

A detailed sketch indicating, when applicable, the elevations of the are to be excavated, nearby or bordering structures, profile of rivers or of submerged waters, exact location of the machinery to be used, warehouse areas, distribution areas or any other facilities whatsoever required for the operation, such as: installation of pipelines, piers, roads, accesses, water intake, wells, sewerage and waste-matter deposits. In case of renewal, express only the changes occurred if the sketch has been previously submitted.

Written authorization by government agencies when any phase of the operation comes under their jurisdiction.

Evidence of the right to perform the activity applied for, as owner, usulractuary, concessionary or leaseholder and/or certified copy of the deed or document, which evidences that right. It will also be required, a Certification from the Registry of the Property, given in the same date and posterior to the application, expressing the name of the person holding title or ownership of the property and, expressing such acts which constitute restrictions or limitations to property rights.

Name and address of the owner or owners of the lands bordering on the place from which the material will be extracted.

A recent air photo utilizing an acceptable technique. In cases of renewal it will not be required if it has been submitted previously, provided however, that is shall be submitted when a controversy requiring it exists.

Section 3.3 – The Petitioner shall submit a detailed exposition of the operational procedures that shall include:

A description of the areas destined to warehousing, processing and distribution of the components of the Earth's crust that may be removed, excavated and/or dredged. Should there be alternate areas, these shall be included for these operations. In case of renewal, only the changes that may have take place shall be expressed.

A detailed description of the equipment and machinery in cases of new operations including the term of delivery of the same and besides, the time that the installation of said equipment will take to be in operations.

A detailed description of the methods that will be employed to remove, excavate, and/or to dredge.

Indicate the accesses or public thoroughfares to be utilized such as streets or roads. In those cases in which in the Secretary's judgment, a significant deterioration might occur in the public thoroughfares to be used as streets or roads, the Secretary may require the petitioner, with the consent of the Department of Transportation and Public Works, to restore to its original state said public thoroughfares or demand the deposit of a bound to guarantee said works before the granting of the permit applied for.

A description of the facilities to be installed to prevent the pollution of the waters or the atmosphere, as well as to preserve the environment and the natural resources in the immediate or adjacent areas.

Indicate the period for which the permit is requested provided that it will not be extended any further beyond the time, for which the right to occupy the property in which the operations will be undertaken.

Indicate in detail if the petitioner or his agents or representatives have been convicted of previous violations, either of his permit of any resolution whatsoever, decision or order decreed by the Secretary, and/or any dispositions whatsoever of the law or regulations promulgated under the same.

Indicate if the petitioner is an association and/or and entity that operates as a non-profit organization and, besides if the petition involves a new application or the renewal of a permit.

The Secretary may request the fulfillment of all other requisites he may deem necessary and convenient to affirm the health, the security, public order or interest and he may likewise dispense with the fulfillment of those which in his judgment would be inapplicable to individual cases.

Section 3.4 – In the permits granted, there shall be included the conditions and limitations relative to the activity that through the same authorized. Said permits shall be granted for a period not longer than one year. In those cases in which the magnitude of the inversion required to carry out the operation on the part of the petitioner, and when the public interest justifies it, there may be granted permits for a period not exceeding three years. The period for which the permit is granted shall begin from the date on which the same was notified to the petitioner. Upon the petitioner's request, the Secretary may change the date of effectiveness of a permit, taking into consideration the time its owner will take to initiate the activities authorized by said permit. When a permit is granted for a period longer than one year, the Secretary may, on his own discretion, review the conditions and limitations consigned therein. If he deems it necessary for protection of the public interest, the Secretary may order any study, evaluation and/or improvements he may deem pertinent, to the owners of said permits that shall be responsible for the cost thereof.

Section 3.5 – The Secretary shall not issue permits to excavate, extract, remove or dredge components of the Earth's crust in those cases in which the ranting thereof be limitedly prohibited by law.

Section 3.6 – The number of permits that the Secretary may grant, totally or in part, to the same person or enterprise, to excavate, extract, remove or dredge components of the Earth's crust hall be limited to four (4) permits. Provided that the Secretary may have the discretion to determine the number of permits to be granted according to the total volume that may be extracted, and/or when by reasons of public policy, it is advisable to be done.

Section 3.7 – Applications for permits shall be filed with the Department of Natural Resources, Permit Division, Box 5887, Puerta de Tierra Station, 00906.

Section 3.8 – In case of application for a new permit and/or its renewal for which the holding of a public hearing is not required or is deemed unnecessary, the Secretary

shall act on the matter within a term of ninety (90) days from the date on which the determination is made that the holding of said public hearing is not necessary. The determination that the holding of a public hearing is not necessary shall be made within a term of twenty (20) days from the publishing of the last edict required in Section 8.1. In those cases in which the holding of public hearings is required, the term during which the Secretary shall be the term stated in the chapter on public hearing expressed further in these Regulations. In any case in which the health, security, order or interest of the public deserve it, the Secretary may issue a provisional permit, in accordance with the terms and conditions that he may deem just and until the application is acted upon by its merits.

ARTICLE 4 – APPLICATION FOR PERMIT TO EXTRACT SAND IN DUNES

In those cases in which a permit for the extraction or removal of sand from the dunes in the coastal zone is applied for, the following additional dispositions shall be applied.

Section 4.1 – Topographic Survey

The applicant shall accompany his application for a permit with a topographic survey of the area to be excavated, fulfilling the following requirements:

Contour lines separated one (1) meter of each other.

Profiles on both ends of the farm and in the interior of the same, in the number that upon the judgment of the Secretary be required for a better evaluation of the case.

Localization of the inter-tidal areas.

Boundaries of private property.

Limits of the proposed extraction.

The altitudes shall bear relation with the man-sea level (M.S.L.) and referred to some know B.M. or any other object of reference in the neighborhood.

Section 4.2 – Dimensions

The residual dunes resulting from an extraction of sand shall meet the following special requirements.

It shall not be less than ten (10) meters in width.

The minimum altitude of a residual dune shall be eight (8) meters keeping in lope IH:IV on the boundary with the extracted area.

The final level of the excavation area shall be not less that one (1) meter above the mean-sea-level (M.S.L.).

ARTICLE 5 – APPLICATION FOR A PERMIT TO EXTRACT MATERIALS FROM THE BED OF A BODY OF WATER

In the case of an application for a permit to excavate, remove or dredge sand, gravel or rock from the bed of a body of water, the following special dispositions shall be applied.

Section 5.1 – Demarcation

In the cases of application for the extraction of materials in a stretch of a river, brook or lake, the Department, as a condition previous to the granting of the permit, shall make a survey of the stretch applied for, which survey shall meet, among others, the following requirements:

Shall clearly mark the boundaries of the riverbed or the drainage area of the body of water, including the safety area or green strip for public use.

Transverse profiles shall be traced at distances not greater than 100 meters.

Fishing areas, bathing areas, recreation areas, natural resources or wildlife reservation areas existing in the neighborhood shall be located.

Section 5.2 – Extraction Limits

No person natural or juridical, may excavate, remove or dredge for profit, materials from the bed of a body of water less than on hundred (100) meters on both sides of any fixed structure within said bed.

The limitations of depth shall be determined by the Secretary in each particular case.

Section 5.3 – New Cases

Whenever an original application to excavate, remove or dredge components of the Earth's crust from the bed of a body of water be filed an Environmental Impact Evaluation (EIE) or Environmental Impact Declaration (EID) when the case justifies it shall be undertaken as a previous condition for the granting of a permit.

ARTICLE 6 – APPLICATION FOR PERMIT TO EXTRACT MATERIALS THAT CREATE PONDS OR LAKES

In the cases where permission is requested for the excavation, removal or dredging of materials from the Earth's crust with the express intention of creating a pond or lake, the following additional dispositions shall be applied.

Section 6.1 – Plans

The applicant shall accompany his application for a permit with a set of plans that shall include, but not be limited to the following requirements:

Survey of the farm where the operation will be undertaken.

Topography Survey of the place to be excavated, with contour lines separated one (1) meter of each other.

Description of what the project will be like, once the operations of extraction and restoration of all the area, are finished.

Graphic description (plans) of the restoration in three stages.

A plan of localization for the processing plant, the warehousing area, dispatching area etc.

The scale of these plans shall be not less than 1:1,000.

Section 6.2 – Environmental Evaluation

As a previous condition to the granting of a permit of this kind, the Department shall effectuate an Environmental Impact Evaluation and if this does not suffice, an Environmental Impact Declaration, where the project's different aspects be discussed.

Section 6.3 – "Performance Bond"

The applicant shall file with the Department a "performance bond" on behalf of the Secretary of Natural Resources, to guarantee the labor of restoration in the area to be excavated and its surroundings. This document will be in force one (1) year more than the duration of the permit. The total payment of the premium thereof, shall be a condition previous to the granting of the permit. The total amount of the "performance bond" shall be determined by the Secretary.

Section 6.4 – Restoration

The applicant is under the obligation of restoring the excavated area and its surroundings through a procedure simultaneous to the operation of extraction. This procedure shall include in all cases the forestation or reforestation of the areas to be restored.

Section 6.5 – Authorization

The applicant shall produce a certification that the owner of the land where the extraction will be undertaken authorizes the creation of a pond or lake in his farm.

Section 6.6 – Limitation

The creation of new ponds or lakes as a result of the extraction of materials at distances less than fifty (50) meters from natural bodies of water or terrestrial communication ways shall not be permitted.

ARTICLE 7 – APPLICATION OF PERMIT FOR THE EXTRACTION OF ROCK

In the cases in which permit for the extraction and removal of rock and its derivatives through the use of explosives is applied for, the following additional dispositions shall be followed:

Section 7.1 – Security Measures

The applicant shall see to it that no fragments of stone and sediments or any other type of waste products whatsoever, generated by the operation of the stone quarry are not deposited on the public ways; that they do not obstruct water drainage, that they do not affect the surface of the wearing course, that they do not undermine the structural stability of the works or the security of transit by public ways and the security of life and property.

Section 7.2 – Use of Explosives

The individual explosives for the extraction, blow-up and removal of stones, shall be controlled in such a way that their magnitude shall not exceed the minimum quantity necessary to perform the programmed work without physically affecting neighboring structures and properties.

Section 7.3 – Timetable for the operation of explosives

The operations requiring the use of explosives shall be carried out from 7:00 A.M. to 6:00 P.M. in those days in which favorable atmospheric conditions prevail. Under special conditions the Secretary shall authorize a different timetable.

Section 7.4 – New Stone Quarries

The outer perimeter of the bottom of new quarries shall be located and kept at a minimum distance of 300 meters (1,000 ft) from the right of way boundary of any public integral part of the operation complex.

Section 7.5 – The dispositions of Section 7.4 shall not be applied if the Secretary verifies the existence of a natural or artificial barrier that project itself not less than thirty meters (30) vertically above the superior level to be exploited, or when in the judgment of the Secretary, specific circumstances do so justify it. The applicant shall submit a detailed description of said barrier, its location and/or circumstances related to the operations public ways and bordering areas. In these cases, the Secretary may authorize the location of the quarry at less than what is specified therein.

Section 7.6 – Method of Extraction

For the cases of extraction of materials in a quarry, the operations shall be performed using the method of banks and terraces.

ARTICLE 8 – PUBLIC HEARINGS

Public hearings held by the Secretary according to Articles 3, 8, 9, 10 and 12 of the Law, shall be ruled by the following norms:

Section 8.1 – In case of any application for permit filed with the Department, and if this complies with the required requisites then the Secretary himself or through the person in whom he may delegate said function, shall prepare and forward to the petitioner or to his attorney, so that the publish in one or more of the newspapers of general circulation that are published in Puerto Rico, a notice that shall contain as a part thereof, the following:

Name and postal address of the petitioner and/or of his attorney if any.

Nature and character of the permit requested stating the locality in which the same is to be held.

Notice to the effect that any person, natural or juridical desiring to appear and be heard, shall file with the Department, on any date within the ten (10) days, subsequent to the date of the publishing of said notice, a document stating in detail the fact on which the right to appear and be heard is based, and if there is any interest in opposing to what has been applied for the motives or reasons for which the permit applied for should not be granted shall be stated.

The Department reserves the right to determine the number of notices that ought to be published in connection with any application for permit taking into consideration, the individual circumstances involved in each application.

Section 8.2 – Any person, natural or juridical, wishing to appear and to be heard in regard to an application for the granting of a new permit, and/or the renewal of one in force, shall file with Department a document duly sworn to stating the following facts:

Name and postal address of the person desiring to appear and to be heard and of his attorney, if any.

Facts on which the right to be heard is based.

This document shall be filed on any date within the 10th day following the date of the publishing of the notice related to the petition provided that, the Department in its discretion may allow the filing of a document to appear and be heard beyond the prescribed term, when on said document be expressed causes which may be considered justified, or when upon judgment of the Department, the public interest does so require it.

Section 8.3 – Notice of Application of Hearing

Any party desiring to appear and be heard shall deliver to the petitioner or his attorney, personally, or send by mail, a copy of the document intended to be filed with the Department, evidence or proof of the due delivery or remission

Section 8.4 – Any person, natural or juridical wishing to appear and to be heard in connection with an application of a new permit or its renewal, shall consign with his application a minimum amount of two-hundred and fifty dollars in addition to the amount mentioned in Section 3.1 of these Regulations, which sum may be upon the discretion of the Secretary, increased, reduced or eliminated if the special circumstances of each case in particular do justify it. An original and two identical copies of the document notified to the petitioner and/or his attorney shall be filed with the Department. After an exhaustive and conscientious study of the document filed by any person or party desiring to appear and be heard, regarding an application of a new permit and/or its renewal, study which shall be made within a reasonable term, it is shown that the final action to be taken on the concession or denegation of a permit will affect the income or the economy, or that it will damage or degrade the environment or the natural systems in the immediate or adjacent area to the place where the excavation, removal or dredging of the components of the Earth's crust were to take place, then, the Secretary will allow the participation and/or the intervention of these parties and shall proceed to notify the petitioner of his intention of ordering a public hearing to be held, and, besides, he shall grant to the petitioner a term of fifteen (15) days to file his answer to the document filed by the person or persons deciding to appear and be heard regarding the application for a permit and/or renewal, by the petitioner. This term of fifteen (15) days to file the answer by the petitioner may be extended or reduced upon the Department's discretion, provided that the special circumstances of the case do so require it. If the petitioner should deny the allegations contained in the document filed by the person that desires to appear and to be heard, then the petitioner's answer shall state all and each one of the facts upon which he basis his denial.

Section 8.5 – The Department may allow the introduction of amendments to any petition, complaint, answer or document filed or presented in any stage of the procedure. Any application for amendment shall be notified to the opposing party, if any.

Section 8.6 – A motion or document of any kind filed as part of a procedure in the Department, regarding any application for a permit or its renewal, shall be notified to the part or parties involved in the procedure and due evidence or proof that said notification has been made, shall be produces.

Section 8.7 – When the case is ready for public hearing, all prescribed steps having been complied with, the Department, on his own initiative or at the request of any of the parties, shall order the assignment for the celebration of the corresponding public hearing. It will be an indispensable requisite for the celebration of any public hearing, that any and all of the interested parties in the procedure, shall have been summoned as they appear on record.

Section 8.8 – When any of the interested parties, as they appear from the record, apply for the celebration of a public hearing in any case, then, the corresponding assignment specifying the place, date and time for the celebration of said hearing shall be ordered.

Section 8.9 – In all public hearings the parties may start the hearing with an exposition in general terms, stating what is intended to be established in the case and/or indicating all the evidence that will be offered and the documents that will be introduced to prove a case, without entering into details regarding the evidence to be produced. The opponent parties may off a similar exposition.

Section 8.10 – The party that applied to appear and be heard, shall first offer his proof and evidence, immediately following, any person who may have intervened in the application for the hearing and/or any other party whose participation the Secretary might have permitted in the hearing and who would favor the position of the party that applied to appear and be heard, shall present their evidence and proof. Then the applicant for a permit or a renewal of the same shall present his proof. Finally, the Secretary upon his discretion may receive any testifical or documentary evidence that in his judgment may shed light to do justice in the matter involved in the case.

Section 8.11 – When authorized by the Secretary, any interested party as it appears from the record, may send questionnaires and take depositions, proved a written application therefore shall have been filed by the interested party, or at the instance of the Secretary proper, in any proceedings whatever, that may be pending before the Department.

Section 8.12 – Only one lawyer for each party shall be allowed to examine and cross-examine the same witness.

Section 8.13 – The Secretary or any examiner that he may designate to preside over the hearing of any proceedings before the Department, may grant suspensions and/or prorogues in the proceedings at the request of any of the interested party as it appears from the record, or on the own initiative of the Department proper. Applications from suspension or prorogue shall be filed not less that three (3) days before the date of assignment of the hearing or the date of expiration of the term required, according to the case.

Section 8.14 – The interested parties as they appear from the record may in any hearing or investigation or in any other proceedings before this Department, through written stipulations filed with the Department, accept all or any of the facts in controversy and said stipulations may be admitted and used as evidence in the hearing, investigation or any other proceedings before the Department. The Department reserves the faculty to require from the parties any additional evidence or information that it may deem necessary for the solution of the proceedings that it may have before it.

Section 8.15 - After all evidence, testimonial and documentary, has been submitted by the parties involved in the case, their lawyers may argue before the Secretary or examiner who presides over the hearing, any point, DE FACTO OR DE JURE they might deem proper to point out to sustain the allegations. The Secretary and/or the examiner may upon the request of any of the parties, or of all of them, grant a reasonable term for them to submit any memorandum sustaining their case, that they may deem convenient to help with the equitable solution of the controversy.

Section 8.16 – All the oral incidences in the public hearing shall be recorded by a stenographer-reporter, and when any of the parties may so apply for it, a copy of the transcription of the record shall be provided after the cost thereof be paid.

Section 8.17 – The Secretary or any Examiner designated by him, may order the celebration of conferences before the hearings between the parties and the personnel of the Department in any matter that may be pending in the Department. Said conferences shall be held before the Secretary and/or the Examiner that he may designate, for the purpose of obtaining any stipulations whatsoever on the DE FACTO and the DE JURE questions, and simplify and other matter before the consideration of the Department so as to arrive to a more rapid and just solution of the controversy or matter at the earliest possible time.

Section 8.18 – The Permits Office of the Department through the persons to the end designated, at the request of any part that shows interest in any proceedings before the Department, shall inform said party about the manner in which any petition ought to be presented, how to answer or file any other document to be submitted as a requisite in any case and shall provide any other information proper for the complete exposition of the material facts regarding any application petition, answer or proceeding before the Department.

Section 8.19 – Nothing of what has been stated in this Article regarding the procedure on the filing of permit applications and/or renewals or public hearings shall be construed as an impediment to the fact that the Department may in any moment whatsoever, suspend of fail to comply with any or all of the requisites set forth in said Sections, in any of the following situations whatsoever:

When upon the Secretary's judgment the matter should be so urgent as to demand immediate action.

When the delay of any action to be taken by the Department is substantially prejudicial or unnecessary.

When no useful and achieved through the observance of said requisites.

Section 8.20 – Once the corresponding public hearing is held and the case submitted to the Secretary and/or to the designated Examiner, for its solution the Secretary within the following ninety (90) days after the case has been submitted, shall consign in writing his decision with the conclusions DE FACTO and DE JURE on which his decision is based and he shall send by certified mail return receipt requested, copy of said document to each one of the appearing parties in the case before the Department.

Section 8.21 – Anyone of the parties adversely affected by a resolution, order or decision of the Secretary, may request its reconsideration within the term of fifteen (15) days from the date of the notification of said resolution, order or decision; said request shall be made in writing duly founded upon and established. In the case that the request for reconsideration may require a reopening of the case, to the end of producing new evidence, in said request for reconsideration the nature and the aim pursued of said new evidence shall be expressed and it shall also express the reasons whereby this evidence was not produced in the public hearing originally held.

Section 8.22 – Any request for reconsideration shall be notified by its proponent to all the appearing parties in the case, who according to the record are interested parties. The proof duly recorded, that said notification was effectuated shall be filed with the Permits Office of the Department, after which the Department, in the case of granting a new hearing, shall set the date, time and place for the hearing and it shall notify said indication to any request for reconsideration without the celebration of a public hearing when from the text of the request it is seen that not sufficient facts are manifested to justify the revision of the judgment, resolution, order of decision of the Secretary.

ARTICLE 9 –

The Department may at any moment, MOTU PROPRIO, or at the request of an affected party undertake investigations and order the celebration of public hearings regarding actions carried out or that might be carried out by any concessionary of a permit granted by the Department and that upon the Secretary's judgment might

jeopardize the order, the health or public welfare and after the celebration of the corresponding quasi-judicial hearing the Secretary shall issue the decree which he considers to be most beneficial to all the parties concerned and in the public interest, including, but not limiting himself to arraign for criminal prosecution according to the provisions of Article 13 of the Law to impose administrative fine in accordance with Article 14 of the Law or impose any other sanction according to the Law.

ARTICLE 10 – DEPOSITS OF SPECIAL PUBLIC INTEREST

In cases of deposits of sand or of any other component of the Earth's crust in lands of the public domain, in which the Secretary judges that there is a special public interest involved, the Secretary shall have the following power that he shall exercise in accordance with the procedure established as follows:

He shall decree a resolution on the ground that the deposit is one of special public interest.

The resolution thus decreed, shall be approved by the Governor of Puerto Rico, after which, it shall be published in three newspapers of general circulation in the Island, once a week during thirty (30) consecutive days.

The Secretary may, from time to time, revise or amend the resolution, declaring a deposit of special public interest, which shall be approved by the Governor of Puerto Rico and published in the same form as the original resolution.

The secretary may revoke his resolution decreeing a deposit of special interest when the circumstances in his judgment do so justify it. The revocation shall be made through a resolution that shall have to be approved by the Governor of Puerto Rico, after which it shall be published in the same form as the original resolution. Any one of these resolutions shall be in force on the day following the publication of the last edict.

He shall fix dates for public hearings to hear those individuals that should have filed permit requests for the extraction of sand and other components of the Earth's crust in the deposits declared of special public interest.

He shall order the publication of notices to the public in not less than two newspapers of general circulation in the Island, once a week during thirty (30) days, the last edict to be published not less than fifteen (15) days prior to the hearing. This notice shall specify the place, day and time of the hearing, and it shall make public that anybody having adverse of favorable interest in the case, may file a document to that effect and shall request permission in writing to be heard not less than ten (10) days prior to the date of the hearing.

The Secretary shall hear the petitioners and in his discretion may grant the permission to be heard, referred to in the preceding paragraph, letter F, but he shall take into consideration all documents of opposition that might have been filled.

The Secretary shall make a special delegation of his powers for the celebration of the public hearings, should he deem it convenient.

Within thirty (30) days following the last public hearing, the Secretary shall issue an announcement of public bid designating date, place and time for the celebration of said public bid, which announcement shall be published in not less than two newspapers of general circulation in the Island, twice a week, and all the petitioners shall be notified thereof by registered mail.

On the appointed date for the bid, the same shall be declared open after a quorum of the board of bids is confirmed. The bidders, present in the hearing, shall submit their propositions in sealed envelopes, expressing the amount they offer to pay for each cubic meter of material to be extracted, provided, that the offer shall not be less than the minimum price designated by the Secretary, according to the Dispositions of Article 11 of these Regulations.

The propositions shall be submitted in a formulary to be provided by the Department, and shall be handed over to the Board of Bids of the Department in the very act of the bid.

After the sealed envelopes with the propositions, have been handed over; the Board of Bids shall open the envelopes and shall read aloud all the propositions for the information and knowledge of the bidders and any other persons having interest, present.

The bid shall be awarded to the best bidder of economic responsibility provided, the Secretary shall reserve for himself the right to reject any proposition or all of them, and in this latter case, he shall hold a new bid following the same procedure of the original bid.

The Secretary shall notify by registered mail to all the bidders the decision that he might take and the bidder or bidders to whom the bid has been awarded shall execute the contract with the Department within ten (10) days from the date of posting in the mails, the notice of award.

The Purchase and Contract Division of the Department shall draw the contract that shall be subscribed to by the Secretary and the petitioner before two witnesses.

The Secretary may approve administratively, standards and rules that will govern the bid proceedings and which shall not be in conflict with the Dispositions of the present Regulations. These rules shall be published once a week at least in two newspapers of

general circulation in Puerto Rico and shall be in force ten (10) days after their last publication.

While the standards and administrative rules referred to in the preceding paragraph P and in all that might be applicable be approved, the rules of the Board of Bids for construction projects of the Department of Public Works, approved May 7, 1968, shall be in force.

ARTICLE 11 –

Every possessor of a permit shall pay to the Secretary of Natural Resources as a part of the fees for the granting of the permit and for the material extracted, removed or dredged in public lands, the amounts stated herein below. Said payments shall be made within the first fifteen (15) days of the month subsequent to the month during which the operations are performed.

For each cubic meter of sand, gravel or stone, requiring to be processed, forty-five cents ($0.45).

For each cubic meter of fill material, or any other material, twenty cents ($0.20).

For each cubic meter of dune sand, river mouth, sand or river sand, not requiring to be processed, seventy-five cents ($0.75).

ARTICLE 12 – TIME LIMITATIONS

The operations of extraction, processing and delivery shall be performed in the hours between 6:00 A.M. and 6:00 P.M. daily except for the following holidays: Every Saturday, Sunday, New Year's Day, Three Kings Day, Good Friday, Fourth of July, General Election Day, Labor Day, Thanksgiving Day and Christmas.

The Secretary is empowered to change this time-table on request of the concessionary, provided, the convenience of said change is justified.

ARTICLE 13 – RECORD OF OPERATIONS

Section 13.1 – To operate in lands of public domain the concessionary shall keep a record of operations in the form required by the SECRETARY and to this effect, he shall utilize notebooks duly numbered, supplied by the Department following a strict numerical order. These records include, but are not limited to:

Name of the selling firm

Date of the sale

Kind of material

Volume of extracted, removed or dredged material delivered

Number of license or license plate of the vehicle transporting the material and the load capacity thereof.

Destination of the material

These records shall be available for inspection by the personnel of the Department when so required.

Section 13.2 – The concessionary shall hand over the original sales slip to the purchaser, who shall keep this document under his care for the chek-up of the origin and destination of the material.

Section 13.3 – The Secretary is empowered to in his judgment inspect the books of the firm that is the concessionary of the permit.

Section 13.4 – The concessionary shall send to the Department together with his monthly report, all of the sales slips of the sales made by him during the month which shall be kept in a strict numerical order.

Section 13.5 – The quantity of material shown by the sales slip and the quantity thereof in the vehicle of the purchaser and transported by him shall be exactly the same.

ARTICLE 14 – BONDS AND INSURANCE

Section 14.1 – In order to operate in lands of public domain, the petitioner shall give a bond, to be established by the SECRETARY on behalf of the Secretary of Natural Resources, for the amount guaranteeing the fees of the material to be extracted during any period of three (3) months. This bond shall be in force during the time in which the permit is in force and it shall be renewed at least thirty (30) days prior to the date of its expiration.

Section 14.2 – The petitioner shall obtain a public responsibility insurance, whenever he may be required to do so, for the amount that discretionally, the Secretary may establish and in which the Department of Natural Resources and/or the Commonwealth of Puerto Rico in the character of an additional insured, shall be included.

Section 14.3 – The petitioner shall produce authentic evidence certified by the insurance company, that the premium of its policy and/or bond has been totally paid and not financed.

Section 14.4 – Any cancellations of policies or bonds shall be notified to the Department of Natural Resources not less than fifteen (15) days in advance.

ARTICLE 15 – RENEWAL OF PERMITS

The application for the renewal of the permit for excavation, removing or dredging of the components of the Earth's crust, shall be submitted in writing to the Secretary of Natural Resources forty-five (45) days before the date of the expiration thereof, in the *pertinent* formulary with original and three copies. The application shall meet all the requirements of the original application, provided, that if there have been no changes in the conditions expressed in the original application, it will suffice to consign it.

ARTICLE 16 – REVOCATION OR SUSPENSION OF PERMITS

The SECRETARY is empowered to revoke a permit of excavation, removing or dredging of the components of the Earth's crust, whenever any of the clauses thereof, be violated, or when upon his judgment, any violation to Law Number 144, and to its regulations might be committed, or when it MIGHT be shown that the revocation would help with the health, the security, or the public order or interest, or when the geological conditions, natural or environmental, existing on the date of its expedition should change significantly and provided, that this variation has not been foreseen in the process of evaluation.

The SECRETARY shall have the power to suspend and/or revoke a permit when upon his judgment the operations of extraction do affect or would affect archeological beds or caves and caverns. The possessor of such permit shall notify the Secretary the presence of the said archeological beds or caves and caverns when the same are discovered during the operations. The Secretary shall order the immediate suspension of said operations until he effectuates an investigation and evaluation of the effects of said operation upon these areas of public interest. When, from said investigation, the need to protect and preserve the afore-said archeological beds, caves and caverns, is made evident, the Secretary shall revoke the permit.

Before revoking the permit, the SECRETARY shall hold hearings of a quasi-judicial nature.

ARTICLE 17 – PERMIT EXEMPTION

The Secretary shall exempt from permits the operations of extraction, removing or dredging of materials from the Earth's crust, when said operations be performed under the following circumstances:

When the excavations, extractions, removals, or dredgings be incidental to, or necessary for the realization of works or projects authorized by Law. When the material

should be given an altogether different use than the one it should be given forth for the realization of the project, an authorization by the Secretary of Natural Resources shall be required, following what is established in Article 11 of these Regulations.

These cases have to be endorsed by the Department as a previous condition to the process for the approval of the work.

Whenever the operations to be performed be the result of natural events such as, landslides in roads, floods, storms, etc.

The Secretary has the power to exempt from permits and from the payment of the amounts that by virtue of the same should correspond, when the quantities extracted are not significant or substantial.

Approved in San Juan, Puerto Rico, this 10th day of October, 1977.

Fred V. Soltero Harrington
Secretary
Department of Natural Resources

Appendix F: Regression Output

One-Step Linear Regression Output From Microsoft Excel

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.946393217
R Square	0.895660122
Adjusted R Square	0.883139336
Standard Error	839525.8126
Observations	29

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.51252E+14	5.04E+13	71.53386093	2.09974E-12
Residual	25	1.76201E+13	7.05E+11		
Total	28	1.68872E+14			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	5871994.805	1784840.303	3.289927	0.002978426	2196049.967	9547939.64	2196050	9547939.643
Trend	-923424.0425	95837.73596	-9.635286	6.75025E-10	-1120805.416	-726042.67	-1120805.4	-726042.669
GDP(constant dollars)	0.004171164	0.00045347	9.198322	1.68411E-09	0.003237225	0.0051051	0.0032372	0.005105103
Mortgage	-259753.9962	80358.88376	-3.232424	0.003431732	-425256.0994	-94251.893	-425256.1	-94251.893

First Step Of Two-Step Linear Regression Output From Microsoft Excel

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.950992225
R Square	0.904386211
Adjusted R Square	0.892912556
Standard Error	62511080.4
Observations	29

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	9.24033E+17	3.08011E+17	78.8228544	7.07907E-13
Residual	25	9.76909E+16	3.90764E+15		
Total	28	1.02172E+18			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-159664654	132899184.3	-1.201396795	0.240855666	-433375455.8	114046147.9	-433375455.8	114046147.9
Trend	-61740809.28	7136076.495	-8.651926493	5.47088E-09	-76437823.64	-47043794.92	-76437823.64	-47043794.92
GDP(constant dollars)	0.31970217	0.033765379	9.468342493	9.54453E-10	0.25016112	0.389243221	0.25016112	0.389243221
Mortgage	-13826477.72	5983521.374	-2.310759309	0.029379918	-26149762.03	-1503193.399	-26149762.03	-1503193.399

First Step Of Two-Step Linear Regression Output From Microsoft Excel

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.930394698
R Square	0.865634294
Adjusted R Square	0.85529847
Standard Error	934192.6387
Observations	29

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.46181E+14	7.30907E+13	83.75087757	4.65318E-12
Residual	26	2.26906E+13	8.72716E+11		
Total	28	1.68872E+14			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7098006.101	555022.8642	12.78867333	1.00953E-12	5957139.517	8238872.685	5957139.517	8238872.685
Trend	-110276.349	22419.4718	-4.918775518	4.16385E-05	-156360.2635	-64192.43453	-156360.2635	-64192.43453
Const. Inv. (constant dollars)	0.012933507	0.000999325	12.94224614	7.70875E-13	0.010879364	0.01498765	0.010879364	0.01498765

One-Step Log Linear Regression Output From Microsoft Excel

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.946092568
R Square	0.895091148
Adjusted R Square	0.882502086
Standard Error	0.071156002
Observations	29

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.079986226	0.359995409	71.10070092	2.24678E-12
Residual	25	0.126579416	0.005063177		
Total	28	1.206565642			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-49.85447905	8.050991481	-6.192340306	1.78037E-06	-66.43579478	-33.27316333	-66.43579478	-33.27316333
Trend	-0.118976283	0.013589533	-8.754993984	4.36747E-09	-0.146964431	-0.090988135	-0.146964431	-0.090988135
ln GDP (constant dollars)	3.080144021	0.365538747	8.426313341	9.00189E-09	2.327303406	3.832984635	2.327303406	3.832984635
ln Mortgage	-0.430795143	0.065812926	-6.545752784	7.40632E-07	-0.566339307	-0.29525098	-0.566339307	-0.29525098