APPENDIX D

SURVEY OF MUNICIPAL SEWAGE TREATMENT PLANTS

GA commissioned a market survey and analysis of wastewater treatment plants which was carried out by graduate students at the San Diego State University (SDSU) School of Business. The objective of the study was to identify near-term wastewater treatment plant clients and to better define market drivers and client needs. A world wide web-based survey was conducted across the U.S. and analyzed to determine the commercialization potential of its SCW technology. The results of the study are presented in this appendix.

General Atomics

Consulting Report on

Supercritical Water Oxidation: Application to Municipal Biosolids Waste Disposal

Prepared By

Lisa Crane
Manjit Gill
Scott Gunther
Vijay Shirsathe

Submitted for Client Approval
On

The Twentieth Day of August
In the Year Two Thousand Two.

Presented in partial fulfillment of the requirements for
the Masters of Business Administration Degree
Graduate School of Business Administration
San Diego State University

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SDSU MBA Business Consulting

Final Report Acknowledgment

I, _____ of _____
(Client's Name) (Name of Firm)

do hereby acknowledge receipt of a copy of the final consulting report that was prepared by the student consulting team from the San Diego State University College of Business Administration.

The team has met and discussed with me the findings of this report. Whereas this report does address the areas of management concern described in the engagement letter, and the team's findings represent valid considerations of these areas that are of utility to our management, this acknowledgment does not necessarily mean that I am in complete agreement with the recommendations.

_____ _____
(Client's Signature) (Date)

_____ _____
(Team Member Signature) (Team Member Signature)

_____ _____
(Team Member Signature) (Team Member Signature)

Engagement Letter

Mr. Lindsey Bierer
Business Development
Advanced Process Systems Division
Advanced Technologies Group
General Atomics
3550 General Atomics Court
San Diego, CA 92186-5608

Mr. Bierer,

On behalf of our student team, I would like to thank you for the opportunity to work closely with you and General Atomics on this project. Among the different program alternatives that were offered, this chance uniquely offered an exciting opening with a well-established international firm. This letter is intended to reflect our understanding of your organization, identify the issue at hand, and clarify the scope of work necessary to complete this project. Chiefly, our goal is to offer valuable market segmentation information for the SCWO process through a market survey instrument. To accomplish this primary objective, three key phases will be implemented:

1) Initiation of a nationwide e-mail market survey for wastewater treatment operators.
2) Collection and analysis of the results.
3) Presentation of study report to key individuals at GA.

Background Information for General Atomics

It is important to first show that the student team has been given a clear impression of the mission of General Atomics. The opening statement to the corporate website describes the nature of the company:

> General Atomics was conceived in 1955 at San Diego, California for the purpose of harnessing the power of nuclear technologies for the benefit of mankind. General Atomics' basic research into fission and fusion has matured into competence in many technologies, making GA and its affiliated companies one of the world's leading resources for high-technology systems development ranging from the nuclear fuel cycle to remotely operated surveillance aircraft, airborne sensors, and advanced electric, electronic, wireless and laser technologies.

Following this stated purpose of using high-technology innovations towards the end of benefiting mankind, Supercritical Water Oxidation (SCWO) has been shown to be an effective alternative to incineration for the destruction of hazardous wastes. General Atomics identifies their company as the leader in the development of SCWO. Initially targeted towards military wastes, the SCWO process has been developed to treat civilian issues such as disposal of municipal sewage sludge. Cost estimates currently under investigation by General Atomics show the process to be competitive with other disposal methods of sewage sludge. Coupling the process with eliminating a costly anaerobic (non-oxygen involved) step in sludge treatment, the savings for municipalities that implement SCWO potentially could be tremendous.

Identification of the Key Target

While the cost advantages of the process are fairly clear, information regarding the size, location, and overall demand for SCWO technology appears to be unorganized, at best. Although the process appears to be of obvious significant value to municipalities across the nation and beyond, identification of the best primary targets of focus has not yet been made evident. Thus, the primary issue for this project is to get reliable data, quickly and accurately, through an appropriate market study.

Project Objectives

***Overall Project Goal*:** Garner deliverable information via an e-mail survey to be analyzed and presented to the client as a market study.

Objective #1: Initiate e-mail survey.

- The student group will **fine-tune** a prepared paper-based survey and **convert it to an electronic version** that can be distributed over the internet
- **Test survey** on local, easily approachable municipal waste managers, as available, for appropriateness, relevance, and accuracy
- A list of appropriate **contacts will be compiled** from available databases of wastewater treatment organizations, among other sources
- **Distribute survey** via e-mail with instructions for completion
- **Offer incentive** to fill out survey, namely feedback on the results across the industry, contingent upon their participation

Sampling Process:

The crux of this step is gaining access to (and feedback from) the key decision-maker at each site location. This is essential because that person will be one of few to be in a position to answer the very specific questions posed by the survey. The project team members are interested in collecting information solely from the key decision-maker at each site. Since the information gathered through secondary channels and existing databases is not anticipated to give exact titles and roles for individuals, an initial contact e-mail will be sent asking the addressee to forward the message to the key person. This premise makes some admitted assumptions:

1) The addressee will actually read the e-mail before trashing a message from an unknown source.
2) S/he will have incentive to forward the tool into the right hands.
3) When the right person does get the survey, s/he completes it promptly.

Steps will be taken to ensure that, to the best of our ability, we will avoid an unexpectedly low rate of return for this survey. The initial **e-mails will be addressed from a student account**, appealing to the academic nature of the situation and giving credibility to the report. **The report, itself, should be clear** enough to be an appreciable

reward for participation. Utilization of **online survey tools** and **a concise survey** should also help to both increase overall response rates and expedite response times.

Should response rates be so low that it impacts the amount of significant data that does become available, some contingency plans have been put into place. Marrying the phone and e-mail contact methods has been mentioned, as has seeking other methods of delivery. At the far end of the imaginative scale, placing a team member at a known industry convention with surveys in hand might yield the most productive data of any alternative, but at considerable cost.

Objective #2: Analyze results.

- **Summarize results** of survey using resources of online survey tool
- **Create tables** with key findings
- Use results to **identify striking factors**, tendencies, and significant data
- **List recommendations** for strategic marketing

Analysis Process:

The online survey tool should make this step relatively simple, with import/export capabilities built in to the service. The $19.95/month rate for www.surveymonkey.com entitles users to advanced tabulation capabilities and tracking information, which our team fully intends to take advantage of. Charting and table creation are also offered as services under the agreement. These will be used to show which areas would lend themselves most easily to opening the market for SCWO, or if the idea has some unforeseen drawbacks.

Objective #3: Prepare and deliver report to clients.

- As stated, deliver analysis to General Atomics contacts

Reporting Process:

The report will be submitted to the client in written and verbal form by the twenty-third of August.

Preliminary Schedule & Deliverables

The objectives stated above will be completed and delivered by August 23, 2002. The table below outlines the estimated start and completion dates of necessary tasks:

Task	Involved Members	Estimated Start Date
Web site completed.	all	7/2/2002
First e-mail sent.	M	7/8/2002
Follow-up initiated (as necessary	all	7/12/2002
All Results tabulated.	all	7/23/2002
Survey tabulation sent to respondents.	M	7/26/2002
Draft report prepared.	L,V,S	7/30/2002
Final report prepared.	all	8/6/2002

* Members: (**L**)isa, (**M**)anjit, (**S**)cott, and (**V**)ijay.

Conclusion

With these objectives met, our student team will deliver information that can be utilized by the client to formulate a market strategy. Obviously, this culminating experience is an opportunity the student team has looked forward to since the beginning of our tenure at SDSU, as it marks the last great hurdle between the group and graduation. We look forward to crossing the finish line in winning style for everyone involved.

Very Respectfully,

Lisa Crane

Scott Gunther

Manjit Gill

Vijay Shirsathe

Your signature is requested to signal agreement on the project objectives and deliverables as stated.

Lindsey Bierer (or qualified representative) Date

Business Development Consultant, General Atomics

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Executive Summary

This study consisted of a web-based survey of 967 director-level employees of Municipal Public Works across the United States and parts of Canada. The survey was delivered through a mass e-mail message to individual contacts found through research on the Internet. The purpose of the study was to collect data and create a market report. Respondents were asked to fill out the survey, which was divided into three sections. A total of 121 responses were received over the course of the survey.

The first section of the survey contained questions regarding the current state of their wastewater treatment facilities. A full 66% of respondents indicated that there was only one treatment plant in their organization. The majority of plants operated as both primary and secondary treatment centers as opposed to just primary treatment centers. The majority of plants were over 15 years old (70%) and the overall population served was generally less than 100,000. Total treatment capacity for the plants averaged 22.75 million gallons per day and the average total biosolids capacity of all plants was 118.49 in dry tons sludge per day. Capacity numbers currently for the average plant are 107.49 dry tons sludge/day, and are expected to remain about the same for the next 10-20 years. The last question from this section was used to determine how financing was most commonly done, with municipal bonds and increased sewer rates coming in on top with 66% and 62% respectively.

The second section quantified the biosolids processing capacities. The most common method for dewatering was belt filters (40%) followed by gravity belts and centrifuge. Staffing was on a 24-hour basis only 35% of the time and digester methane was usually either flared (47%) or used for digester heating (49%). System operation of the power generator had a ratio of 15:1 for plant staff to contractor help. Only 14% of the respondents claimed that they had industrial neighbors that could use their by-products.

Section three was the last section of the survey and dealt with the biosolids disposal process. Over 76% of the systems had one or more biosolids disposal facilities. Land amendment was clearly the most common disposal method at 71% followed by landfill (28%) and then composting (8%). Current sludge disposal costs averaged $114.07 although the median value is far below at $54. Nearly half of the respondents were considering new methods for disposal. The significant driving forces for

management were regulatory, disposal costs, and land shortage. More than half (56%) of the respondents were interested in Super Critical Water Oxidation (SCWO) and a full 75% indicated that they would like to receive additional information on the technology.

Careful analysis of the results discussed above led the team to several informative conclusions. Judging from the exceptionally high response rate to the survey and from responses within the survey, it was inferred that there is significant interest in a new technology that can efficiently solve current municipal biosolids disposal problems. The state of the current facilities depicted by the survey suggested that a large percentage of the target market have relatively old facilities. Regulatory pressures and high disposal costs appeared to be the driving factors that cause municipalities to consider more cost-effective and environmentally efficient disposal methods. All of these factors combine to indicate that the time seems to be right for a new technology such as SCWO to fulfill the market need mentioned above. We conclude that General Atomics can compete successfully in this environment given their considerable expertise and experience.

The student team also concluded that there were several indicators that marked tendencies for plants to be more interested in SCWO. These included plants that were (1) older than 30 years; (2) serving populations of 100,000-499,999 or over 1 million; (3) using gravity belts or centrifugation for dewatering; (4) employing five or more personnel; (5) using landfill or land amendment as disposal method; and (6) driven by regulatory forces or disposal costs.

The student group has several recommendations that came out of this market research. First, it is suggested that General Atomics actively pursue municipalities that fit the categories listed in the conclusions above. Those cities are shown to be more likely to have an interested in SCWO. By targeting plants that may already be interested, selling costs can be minimized and the target range can be focused. Second, it is recommended that General Atomics begin to educate the market about SCWO. Education will help bring attention to the technology as a viable alternative. The third recommendation is to suggest an alternative method for identifying potential customers. The current method was to begin sorting based on respondent interest. Unfortunately, survey results showed several respondents listed themselves as "uninterested," even though they would appear to benefit greatly from SCWO from a financial standpoint.

This means that there is a portion of the market that could be swayed by informative selling techniques. By starting the sorting process from a financial benefit perspective, some more candidates may be found. Lastly, it is also recommended to carry out further analysis on the raw data collected through this survey. Several of the answers to open-ended questions gave good insight into the motivations of municipal directors, but were not able to be quantified and captured. Reading through this feedback will give General Atomics a better understanding of the potential customer.

Introduction

Supercritical water oxidation (SCWO) is an emerging technology that promises an efficient and environment-friendly biosolids disposal method. This report comprises of market research that evaluates the market feasibility of this technology. The research was conducted via an Internet-based survey.

It is important is to stress the significance of the information that can be gleaned from a few people answering some questions for a student survey. An illustration was made in a recent article gracing the Sunday headline of a nearby newspaper, The Orange County Register, stating simply, "Sewage treatment on tap." Pat Brennan, a staff member of the Register, authored the article and clarified several of the issues involved.

The subject revolves around a single district in Orange County that serves approximately 2.2 million people in the area's region. These end-users are the beneficiaries of the current sewage system that exists and would all be affected if any policies were changed by the local elected officials who run the system.

Ecologically, the impact of the current system has come into question. Several of the beaches in the area have become polluted with high levels of biologics and the cause is unclear. Some experts suggest that the sewage treatment and its flow from off-shore release points is the culprit, while others believe the "plume" of treated sewage that is released several miles off-shore to be innocent of the crimes it is accused of committing.

Public perception is the vehicle that may decide how the cities affected will come to a conclusion on the best solution to this problem. Regardless of factual evidence, sometimes an idea is just too abstract for the common voter to accept. Brennan shows that upgrading the current system may do nothing to actually change the effects and contaminations, but simply installing them will allow the taxpayers and beachgoers alike to sleep a little easier, and allay some of their fears.

The most compelling factor is the money that is at stake. The numbers that are being discussed right now are that "it could take as long as 11 years and cost an estimated $423 million, to be paid for by sewer rate hikes for home and business owners." If you realize that this is just for a single operation and that tens of thousands of similar situations exist around the nation, you can understand that this is BIG business! If

supercritical water oxidation can be tailored to be a viable option for either eliminating pathogens, reducing costs (or both), there is clearly a great deal of opportunity available.

This project is intended to give the client, General Atomics, enough information to determine whether there is money to be made using their technology. Blanketing the nation will paint a picture of the overall market and can make entering this market a confident move, or justify the decision to pursue other interests.

Background

General Atomics (GA) is an industry leader in developing an efficient technology called Supercritical Water Oxidation (SCWO), which is used to treat a wide range of hazardous wastes. General Atomics would now like to commercialize this technology for widespread treatment of more benign waste applications. One such application would be the disposal of municipal sewage sludge in an environmentally sensitive and cost effective manner. Disposal of sewage sludge is costly for municipalities that do not have their own facilities and a capacity battle for those that do; furthermore, disposal options are decreasing while disposal costs are increasing.

Modern wastewater treatment plants utilize aerobic digestion of activated sludge as the primary treatment method for reducing biological matter in wastewater. This enables the water to be safely returned to the environment. Sewage sludge that accumulates from the water treatment process is often treated in anaerobic digesters to reduce the biological activity and quantity of sludge. Output from the anaerobic digestion process is methane General Atomics, which can be collected and used to produce heat and/or power, and residual sludge depleted of most of its biological activity. This sludge is thickened and de-watered in a centrifuge or belt press to a moist consistency that can be transported by truck to the disposal site.

SCWO is an efficient and clean alternative to traditional sewage sludge treatment and disposal methods. The SCWO system would be integrated into the overall operation of the wastewater treatment plant. The most cost-effective way to introduce SCWO into plant operations is to bypass the anaerobic digestion process and send the sewage sludge directly to the SCWO system. The sludge should first be thickened and de-watered to about 10% solids by weight. With sufficient recuperative heat recovery, this sludge concentration is sufficient to fuel the SCWO process, enabling efficient, cost effective and environmentally friendly destruction of the sludge.

Cost studies are currently underway at General Atomics to estimate the SCWO treatment costs for disposal of sewage sludge. Current estimates appear to be competitive with other sludge disposal methods. Therefore, it appears that a potential market exists for the sale of SCWO systems to municipal wastewater plants for disposal wastewater treatment plants to destroy the sewage sludge in compliance with environmental requirements and at an overall cost savings.

Market Situation

This section attempts to paint the picture of the current market situation as it is currently understood. All of the information discussed below has been extracted from several documents published on various websites listed in Appendix F.

Solid Waste Management (SWM) planning by each municipality must take into account the following items:

- The total amount of municipal waste generated
- The amount of that waste stream to be controlled by the local implementing agency or agencies
- The method or methods selected to manage that portion of the waste stream
- The various collection, processing and disposal options available
- The extent to which some or all of those options are currently being provided and who the providers are
- The advantages and disadvantages of public ownership and control versus market-based private sector completion
- The balancing effort of market forces brought about by a competitive process
- The environmental impacts of the various alternatives
- The cost associated with each alternative

The economics associated with any of those alternatives and regulatory forces heavily influence the planning process. The U.S. Environmental Protection Agency (EPA) has established a hierarchy of preferred SWM technologies. Many similar state

and local guidelines or mandates can be found in state waste management acts. Most SWM hierarchies include the following alternatives in the decreasing order of preference:

- Waste reduction at the source
- Recycling and reuse
- Resource recovery
- Land filling

In concert with this hierarchy, the management of Municipal Solids Waste (MSW) should focus on reduction, reuse, recycling, and energy-recovery and divert the waste from the least desirable option, land disposal. During the past decades municipal governments have invested in advancing from unregulated disposal of waste to a more controlled environment. The main focus of this transition has been to close uncontrolled land disposal sites and shift to more environmentally sound land disposal facilities.

Applying this trend to the treatment of biosolids, many municipal establishments have implemented various biosolids stabilization processes. Products of such processes are compost, liquid sludge, sludge cake, lime-stabilized biosolids, and thermally dried biosolids. Various markets for these products include compost, for horticultural and landscaping industries, application to agricultural lands, and site remediation. Markets for composted products are limited to high quality products, which must meet horticultural standards. The compost markets are limited, and over-supplied with other products such as green waste. Further, composted biosolids are distributed directly to the public, which increases the risk of pathogen infection if the composting process does not completely destroy the pathogens.

The markets for large volumes of stabilized biosolids are agriculture, and to some extent, site remediation. Sewage sludge used in agriculture also requires tighter concentration limits for heavy metals in the sludge and the possible inclusion of limits for persistent organics. Application rates of biosolids are determined by agronomic and contaminant application rates. Land application of Grade B stabilized de-watered cake is

the least cost option, however the biosolids must be digested to reduce odor and vector attraction. Further, recent studies in Denmark indicate that the beef tapeworm may survive in de-watered cake treated lands for more than one year. The USA National Research Council in "Use of Reclaimed Water and Sludge in Food Crop Production, 1996" considers that the withholding period for animals after land application of de-watered cake should be reconsidered.

Incineration of biosolids is yet another alternative followed by some of the establishments. However, increasingly stringent requirements on air emissions impose huge barriers to this option.

Given this picture of the biosolids treatment methods deployed throughout the United States, the story of SCWO technology appears even more compelling. A few companies such as Chematur Engineering and Hydroprocessing LLC are currently attempting to market the SCWO technology for the treatment of biosolids. The advantages that SCWO holds over conventional methods can be described as follows:

- Complete destruction of sludge with minimal residuals
- No concentrated return streams
- Reduction of odor and noise
- Cost effectiveness (enhanced by the sale of benign byproducts)
- Overall improved wastewater treatment plant operations

Market data

Biosolids treatment plants or facilities for various municipalities appear to exist in different forms. Some of the forms are mentioned below:

- Public ownership and operation of all required equipment and facilities
- Public ownership and operation of collection equipment and contract for private operation of publicly owned transfer, processing (materials recovery, composting, waste-to-energy) facilities and/or disposal (landfill) facilities

- Public ownership and operation of collection equipment and contract for use of privately owned and operated transfer, processing facilities and/or disposal facilities
- Private ownership and operation of all required equipment and facilities through service contract with the public sector
- Private ownership and operations of all required equipment and facilities through direct contracts between the individual generator and the private sector supplier

In general, sewage facilities have been categorized under SIC 4952. Corresponding NAICS number is 221320. D&B Industry Report (see reference in Appendix F) for this SIC gives a brief financial overview of the market size. As of 2002, there are an estimated 1,863 total number of facilities employing 31,662 people. Total annual sales in the industry are reported in excess of $3,557.5 million. Geographical distribution and detailed information regarding these 1,863 facilities can be found in the report.

Problem Statement

The problem statement for this field study can be stated as follows.

Currently, there is a scarcity of market information with respect to several aspects of the municipal waste treatment market. Chiefly, (1) the general age and makeup of existing waste treatment facilities is unknown, (2) the driving forces in sludge management strategy have not been elucidated, and (3) the general interest in new technologies, such as SCWO, is also in question.

Along with the financial feasibility study that is currently underway, General Atomics must also define the appropriate target market within the $3.5 billion sewage facilities market. Of the thousands of municipalities that exist today in the United States, no single process for wastewater treatment exists. Rather, each municipality must base their decisions on their own unique set of criteria. General Atomics' goal in determining an appropriate target market will be facilitated through an understanding of the various decision-making processes for municipalities and what similarities exist. In order to determine technology selection criteria and potential demand for SCWO technology, it is necessary to collect and analyze relevant market data from the decision-makers at these facilities. This type of primary research would assist General Atomics not only in target selection but may also point out areas where their technology could be tailored to better serve the market or even expand the market.

Project Objectives

As discussed earlier, this project dealt with the market research for the municipal solid waste disposal industry. The desired goal was to collect as much data as possible on the state of the current MSW treatment facilities in order to find out whether a potential exists for introducing SCWO to this market. Based on past experiences, General Atomics had concluded that an e-mail-based survey was an appropriate methodology to conduct this research. However, after discussion with the SDSU student team and Professor Sciglimpaglia, it was determined that a web-based survey would be the most appropriate method for this market research due to the nature of the BA795 format, which was limited in both time and budget. Additionally, current web-based survey technology offered advantages over traditional survey methods, such as automatic data collection and basic data tabulation. Therefore, a web-based survey was conducted and the results analyzed in order to determine the commercialization potential of General Atomics' SCWO technology.

The primary objective was as follows:

Garner deliverable information via an e-mail survey to be analyzed and presented to the client as a market study.

In order to achieve the overall objective mentioned above, it was necessary to define several secondary objectives. These secondary objectives were helpful in setting up intermediate milestones and provided tangible measures of the overall progress of the project.

First, a survey questionnaire had to be prepared with assistance from General Atomics and SDSU professors. The questionnaire was formatted to be simple enough for the respondent to answer quickly, but detailed enough to get informative data. Fine-tuning this instrument was critical for the rest of the project to work effectively.

Assuming a 10% response rate and that about 100 responses were required for effective analysis, the student team built a nation-wide database of approximately 1000 e-mail addresses. These addresses had to be from specific personnel (Director-level or

above) for each municipality, since each Director would be one of the few people who could answer the questions accurately.

Another secondary objective was to conduct the survey with an ability to track responses in real time. Due to the limited amount of time available, it was crucial to monitor the response rate and take appropriate actions, such as reminder e-mails or phone calls if the 100 response pre-set threshold was not met. Fortunately, no further contacts were needed other than the primary emails.

Once the survey had enough of a response from the nationwide set of recipients, the goal was set to analyze results in light of the problem statement discussed earlier. Creating the summary of key findings for General Atomics' use allowed the student team to draw conclusions and test the validity of the work performed.

The final objective was to prepare and deliver a detailed report and summary presentation to General Atomics and San Diego State University. Recommendations for future actions will be made at this time.

Methodology

The previous section delineated the overall project objectives and a number of secondary objectives that provided the student group with a roadmap in this study. This section describes the approaches and methods used to achieve each project objective.

The first step in this project was creating a survey that would to obtain the most relevant information from the respondents. General Atomics suggested structuring the survey into the following three general areas of interest:

(1) **Wastewater facilities information** – Questions in this section of the survey were targeted towards determining the current and future planned capacity of existing treatment facilities. This information is particularly helpful gaining an understanding of the size and age distribution of existing treatment plants. This section also determines overall population served, capital improvement financing methods and sewer rate charges.

(2) **Biosolids processing information** – Questions in this section reveal details regarding the current processing methods used by the existing plant. This information is intended to help General Atomics in gauging whether or not SCWO is a technically superior alternative for the respondent. Specifically, this section surveys the respondent in terms of solid levels currently attained, number of plant personnel, uses for digester methane, and if near-by industrial neighbors have a use for the byproducts created by SCWO.

(3) **Biosolids disposal information** – Questions in this section are meant to identify the number of biosolids disposal facilities in each system, the biosolids disposal methods used, sludge disposal costs, current consideration of different disposal methods, most significant driving forces in sludge management strategy, interest in different sludge disposal methods and more specifically, their interest in SCWO.

The web-based survey questions were created with the assistance of General Atomics management. A base set of survey questions was provided by General Atomics and fine-tuned by the SDSU team. Because none of the team members were technical

experts in the SCWO process, it was difficult to provide any technical input on the survey questionnaire. As a result, only minor changes were suggested that made survey more conducive to a web-based format. The next step was selecting the online survey tool. It was deemed necessary that such a tool should make the survey rollout process relatively simple, with data import/export capabilities built into the service. The name of surveymonkey.com came at the top of the recommended survey tools. The $19.95/month rate for http://www.surveymonkey.com entitles users to advanced tabulation capabilities and tracking information, which we intended to use. A copy of the service agreement can be found in Appendix E. Charting and table creation is also offered as services under the agreement. After initiating our surveymonkey.com account, we converted the paper survey into an electronic version and designed the visual layout in accordance with General Atomics' preferences.

Although surveymonkey.com offered some customization features, there were limitations to it. For example, we would have liked more customizable attributes for each database entry. However, surveymonkey.com allowed only one custom attribute. As mentioned before, the answers for some questions appeared to be incompatible with previous responses. Adding some "logic" to the tool would have helped to make some answers make more sense. For example, some respondents answered that they had more than ten (10) processing plants in the organization, yet only listed two (2) primary- and five (5) primary-and-secondary treatment plants (which doesn't add to ten!) in the following question.

The web survey was tested several times by sending the web link to known respondents and having them take the survey. Results were collected and tested in real time. The valuable feedback from the respondents was incorporated into the survey. This practice helped the SDSU team to perfect the survey rollout procedure and enhance the confidence in the survey tool.

Parallel to this effort, we created a database of contacts. These contacts were determined through extensive Internet searches. Since we were a team of four people, we divided the fifty United States and ten Canadian provinces into four lists and distributed it amongst the team in order to avoid overlap. Then began the lengthy process of carrying out in-depth Internet searches in order to gather e-mail addresses for the Director of

Public Works for the municipalities of various cities and counties that operate wastewater treatment plants. Each team member had a target of 250 e-mail addresses in mind and care was taken to cover as much geographical area as possible while collecting the information. We took care to collect the phone numbers in addition to e-mail addresses so that the person could be reached via phone if the response rate did not meet our expectations. The team agreed in advance on the exact format of all the contact data collected by each team member so that it would later be easy to upload it into the surveymonkey.com database.

Throughout this effort, several key steps were taken to increase the response rate for this survey. We made our best effort to identify the specific e-mail address of the Public Works Director for municipalities nationwide, rather than a general contact e-mail address. We were successful in compiling a database of 967 contacts across the United States and parts of Canada. Another step taken to increase response rate was addressing the e-mails sent to potential respondents from an SDSU student account, appealing to the academic nature of the situation. Professor Sciglimpaglia allowed us to use his name and contact information in the e-mail for respondents wishing to verify the authenticity of the study. It was also decided to offer incentive to fill out survey, specifically, feedback on the survey results to participating respondents. Finally, utmost attention was given in the web survey design to ensure that the survey would not take more than twenty to twenty-five minutes. A copy of this finalized questionnaire can be found in Appendix C.

Logistics of rolling out the survey involved various alternatives and the following is a description of the eventual rollout. First, an introductory e-mail was sent out to each e-mail address in the database; a copy may be found in Appendix B. This e-mail described the nature of the project, invited them to participate in the survey and provided a web address for their prompt participation. We experienced a strong initial response, in fact, 30 of our contacts responded within 24 hours and 61 within 48 hours. This first batch e-mail also resulted in the return of many e-mails, indicating invalid e-mail addresses. An e-mail reminder followed the initial e-mail by approximately two weeks. This e-mail can be found in Appendix B. Although we had selected a relatively uniform sample throughout the USA, an even geographical distribution of the respondents could

not be guaranteed since this was an e-mail based survey. This limitation appears to be relatively insignificant, though, in light of our mapped data points. The large number of quality contacts that we did collect may have mitigated the possible downside, as well.

Upon surpassing our target of 100 respondents, we ended the survey on July 27, 2002 with 121 survey participants. Of our total survey recipients of 983 (967 Initial + 16 Secondary), the 121 survey participants represent a response rate of 12.3%. This is an order of a magnitude larger than the 1-2% response rate for a typical email survey. We then began the data reduction and analysis portion of the study. The raw data and tables provided by surveymonkey.com were exported from their Internet location into an Excel file on a team member's local system. A copy of the raw data that was collected has been sent to Carol Smith. Some of these data were then reduced and altered so that responses to open-ended questions were in a similar format. Initially, each question was considered independently of the others and an appropriate table or chart was created in order to visualize these results. In several cases, input was required from General Atomics in order to determine appropriate data ranges. Upon completion of the individual question analysis, we then considered the two "deal-breaking" questions in the context of other questions and determined the appropriate cross-tabulated tables that should be created. The critical questions asked if the respondent was considering new disposal methods and if he/she had an interest in SCWO. Specifically, we cross-tabulated the results for these questions with questions from each of the survey's three general sections. These tables were created by utilizing both the "Auto Filter" and the "Summary Statistics" functions within Excel and can be found in the results section. The questions mentioned above clearly indicate interest in new or different sludge disposal methods and interest or potential use for SCWO, respectively. The analysis of these two questions against the remaining questions revealed a general profile for the types of municipalities that are interested in new biosolids disposal methods, SCWO technology, or both. This table is presented and discussed in the Conclusions section of this report.

Mapping of respondents was a difficult task. Responses were automatically labeled by surveymonkey.com with the respondents' computer IP addresses. Marking

IDs in this manner helped the team protect the integrity of the data, preventing duplication of answers or forgery of information. These numerical addresses were broken down into components and matched to corresponding latitude and longitude points. The points were then simply (but painstakingly manually) mapped on the chart that appears in the results section that follows. We believe that this information visually gives a good insight into concentrations of interested parties (those who took the time to fill out the survey) and elucidates the range of areas that the student team blanketed. Copies of the maps can be found in Appendix A.

The final step of the team's method was to report back to respondents and deliver on our promise of feedback. A copy of our final contact letter is found in Appendix B. Included in the final contact was a brief note of appreciation for the contribution, an edited matrix of the data (to protect the user's identities) and a message directing them to a contact at General Atomics if they want any further information. This allows all parties to maintain their ethical obligations, as the student team can keep the integrity of the academic nature of the assignment intact, and still allow for contact between General Atomics and potential clients to be fostered, at the discretion of each municipality's public works director.

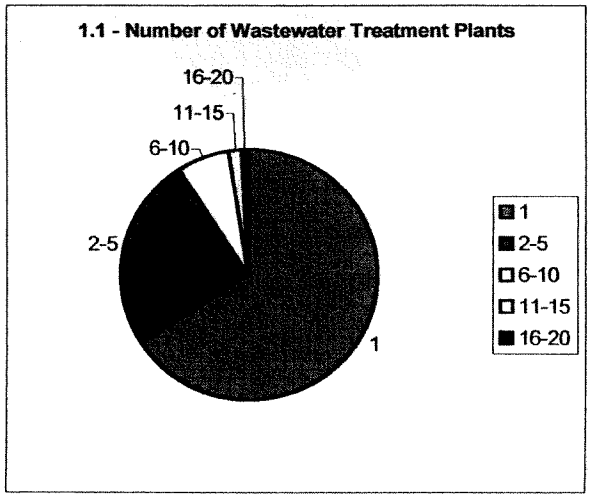
Results

The results of this study are discussed in two sections. The first section illustrates the results of the individual survey questions in a graphical format. A pie chart has been chosen to represent the data to help convey the greater market picture, and helps show general tendencies. The second section describes the cross-tabulated tables created in order to address areas of interest specific to General Atomics. This cross-tab format helps show more target-specific information.

Section 1 – Individual Question Results

Wastewater Treatment Facilities (Questions 1.1 – 1.10 of the survey)

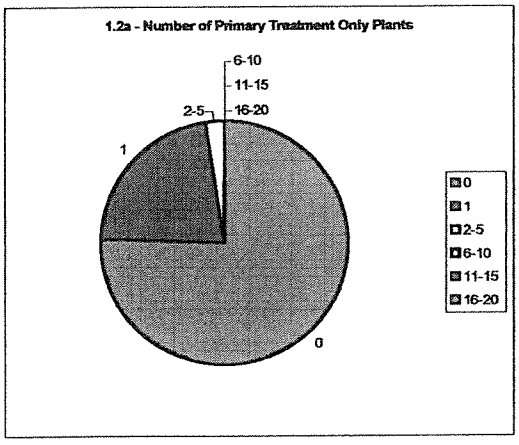
Question 1.1: How many wastewater treatment plants are in your organization?



1.1	# of Plants	Response Quantity	Response Percentage
	1	79	66%
	2-5	30	25%
	6-10	8	7%
	11-15	2	2%
	16-20	1	1%
		120	100%
	Response Rate	99%	

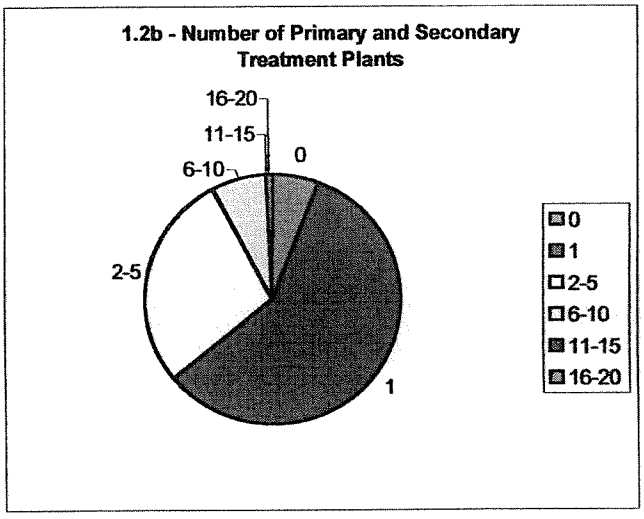
Respondents indicated that there is typically one wastewater treatment plant per organization, with a 66% majority.

Question 1.2a: How many treatment plants are: Primary Only?



1.2	# of Primary Treatment Plants	Response Quantity	Response Percentage
	0	31	76%
	1	9	22%
	2-5	1	2%
	6-10	0	0%
	11-15	0	0%
	16-20	0	0%
		41	100%
	Response Rate	34%	

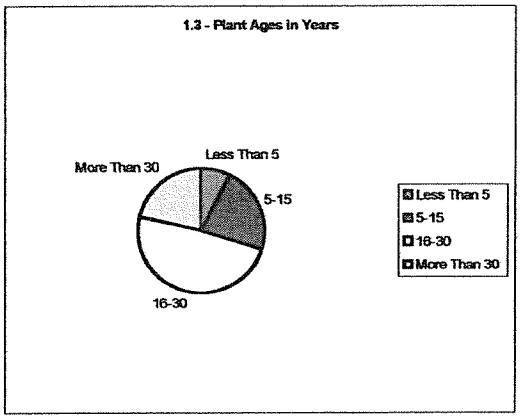
Question 1.2b: How many treatment plants are: Primary and Secondary?



1.2	# of Primary and Secondary	Response Quantity	Response Percentage
	0	6	6%
	1	60	58%
	2-5	29	28%
	6-10	7	7%
	11-15	0	0%
	16-20	1	1%
		103	100%
	Response Rate	85%	

This question indicates that there are relatively few "primary treatment only" plants. Of the few that exist, most (90%) are the only treatment plant in the organization. Also, plants that were both primary and secondary treatment facilities were most likely the only plant in an organization.

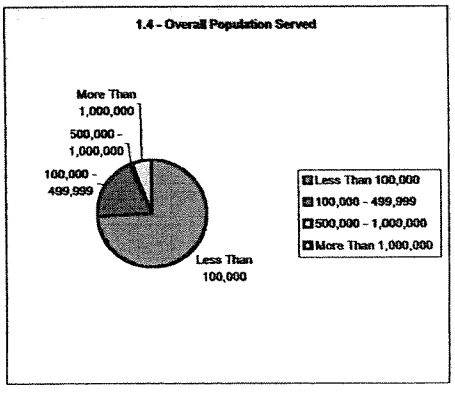
Question 1.3: How old are the existing plants?



1.3	Plant Age	# of Plants	Response Percentage
	Less Than 5	19	8%
	5-15	56	22%
	16-30	124	49%
	More Than 30	54	21%
		65 --> 253	100%
	Response Rate	54%	

This question indicates the general age of equipment currently utilized by the respondents. The results reveal that nearly half of the equipment is between 16 and 30 years old and another 21% are more than 30 years old.

Question 1.4: What is the population being served?



1.4	Population Served	Response Quantity	Response Percentage
	Less Than 100,000	78	74%
	100,000 - 499,999	20	19%
	500,000 - 1,000,000	1	1%
	More Than 1,000,000	6	6%
		105	100%
	Response Rate	87%	

Nearly three-quarters of the respondents were serving less than 100,000.

Question 1.5: What is the total treatment capacity (gallons per day)? What is the number of separate plants?

1.5

Treatment Capacity	Gallons per Day (MM)	# of Plants
Average	22.8 MGD	1.9
Median	7.5	1
Range	0 to 450	0 to 16
Response Rate	80%	

The responses to this open-ended question reveal that an average of 22.8 MGD of waste is treated by an average of 1.9 plants per facility.

Question 1.6: What is the total biosolids capacity of all plants?

1.6

Biosolids Capacity	Dry Tons per Day
Average	118.5
Median	5
Range	0 to 2000
Response Rate	61%

The responses to this open-ended question reveal an average biosolids capacity of 118.5 dry tons per day.

Question 1.7: What is the planned capacity for the next 5 to 10 years?

1.7

Planned Capacity - Next 5-10 Years	Dry Tons per Day
Average	107.5
Median	6.6
Range	0 to 2000
Response Rate	60%

The responses to this open-ended question reveal an average biosolids capacity of 107.5 dry tons per day. The decrease in planned capacity is of interest and may indicate an error in the question.

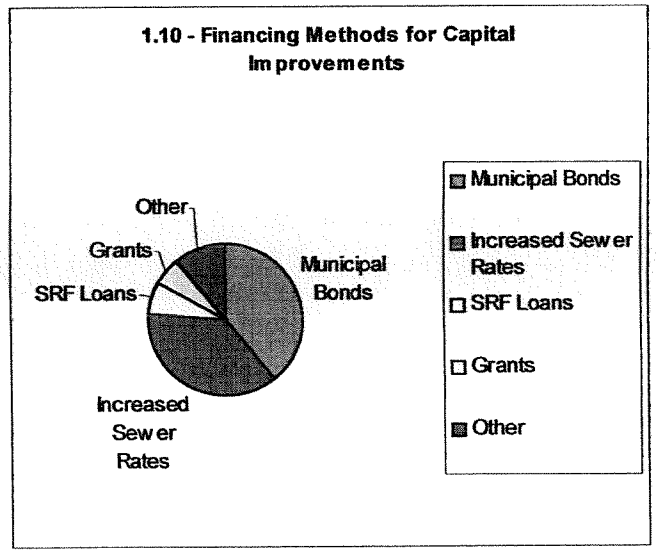
Question 1.8: What is the planned capacity for the next 10 to 20 years?

1.8	Planned Capacity - Next 10-20 Years	Dry Tons per Day
	Average	123.86
	Median	6.83
	Range	0 to 2000
	Response Rate	60%

Question 1.9: What are the current residential and commercial sewer rate charges?

The results to 1.9 can be found in Appendix D. The open-ended nature of the question resulted in responses not suitable for performing statistical calculations.

Question 1.10: How are capital improvement costs financed?

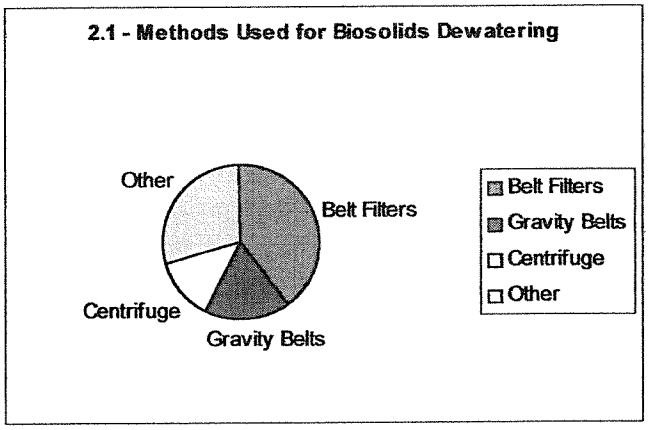


1.10	Financing Method	Response Quantity	Response Percentage
	Municipal Bonds	54	66%
	Increased Sewer Rates	51	62%
	SRF Loans	10	12%
	Grants	8	10%
	Other	15	18%
		82 –> 138	168%
	Response Rate	68%	

This last question from the first section shows that financing for capital improvements is primarily done through municipal bonds and increased sewer rates, with grants and loans rounding out the other methods. Respondents chose multiple methods in many cases. 138 responses were received from 82 respondents.

Section 2 - Biosolids Processing (Questions 2.1 – 2.7 of the survey)

Question 2.1: How many treatment plants use the following types of biosolids dewatering?



2.1	Dewatering Types	# of Plants	Response Percentage
	Belt Filters	49	40%
	Gravity Belts	21	17%
	Centrifuge	16	13%
	Other	37	30%
		48 –>123	100%
	Response Rate	40%	

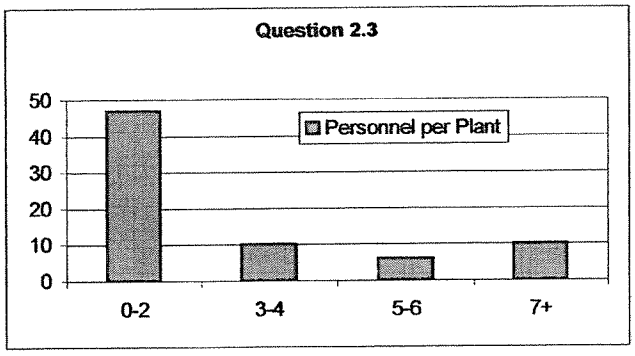
This question reveals that methods used for biosolids dewatering are primarily belt filters and other methods. Respondents chose multiple methods in many cases. 123 responses were received from 48 respondents.

Question 2.2: What solid levels are currently attained (in %)?

2.2	Solid Levels	%
	Average	19.43
	Median	18
	Range	1.6 to 98
	Response Rate	63%

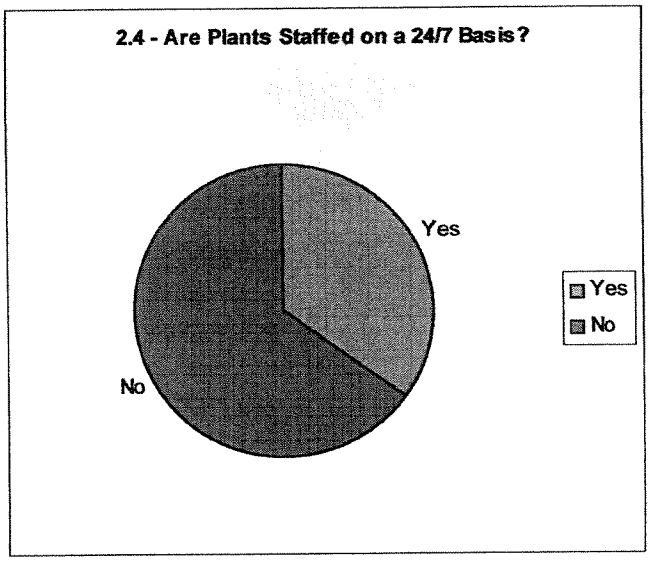
The solid level range is very high, but the average level is within expectations.

Question 2.3: How many operations & maintenance personnel are assigned to bio-processing at each plant?



Over 45 of the 73 total respondents have 0-2 personnel per plant.

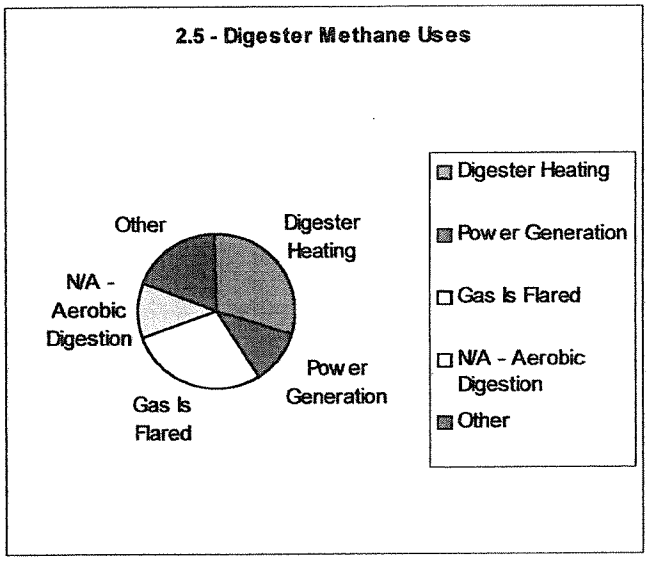
Question 2.4: Are plants staffed on a 24/7 basis?



2.4 Staffed 24/7?	Response Quantity	Response Percentage
Yes	29	35%
No	54	65%
	83	100%
Response Rate	69%	

The typical plant is not staffed on a round-the-clock basis.

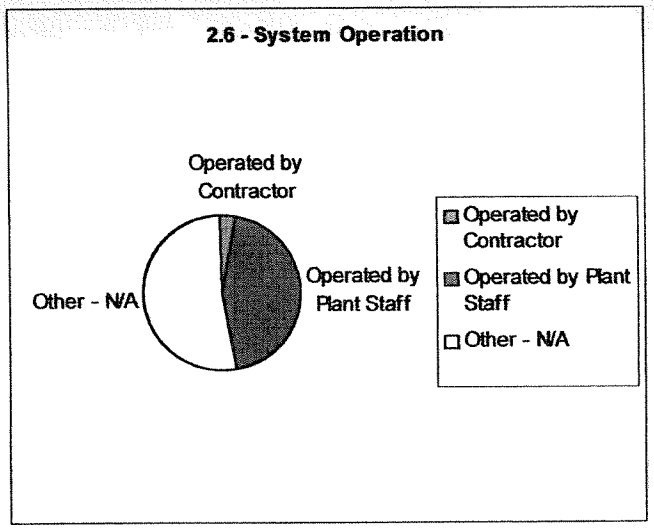
Question 2.5: How is digester methane used?



2.5	Digester Methane Uses	Response Quantity	Response Percentage
	Digester Heating	36	49%
	Power Generation	13	18%
	Gas Is Flared	34	47%
	N/A - Aerobic Digestion	14	19%
	Other	23	32%
		73 --> 120	164%
	Response Rate	60%	

This question reveals that digester methane is primarily used for digester heating and gas flares. Respondents chose multiple methods in many cases. 120 responses were received from 73 respondents.

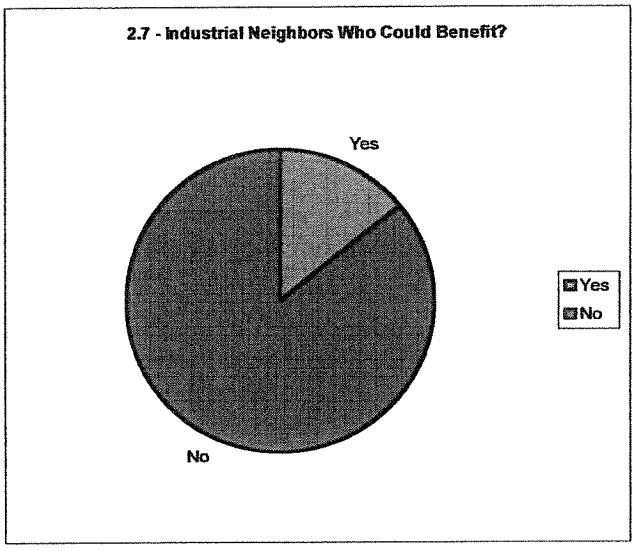
Question 2.6: Who operates the methane-powered generators?



2.6	System Operation	Response Quantity	Response Percentage
	Operated by Contractor	1	3%
	Operated by Plant Staff	15	44%
	Other - N/A	18	53%
		34	100%
	Response Rate	28%	

In general, it appears that using staff members is more common than the practice of hiring a contractor. It is important to note that 53% of respondents used a different method or felt that the question did not apply to their operations.

Question 2.7: Are there near-by industrial neighbors who might be able to use plant steam, power, CO2 or other products from the wastewater treatment plant?

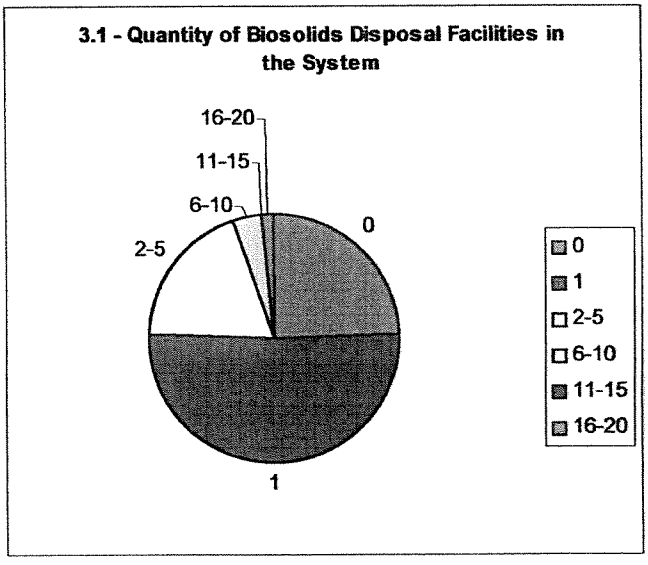


2.7	Industrial Neighbors?	Response Quantity	Response Percentage
	Yes	11	14%
	No	66	86%
		77	100%
	Response Rate	64%	

In general, respondents do not believe that they have industrial neighbors who can use the byproducts of SCWO.

Biosolids Disposal Process (Questions 3.1 – 3.9 of the survey)

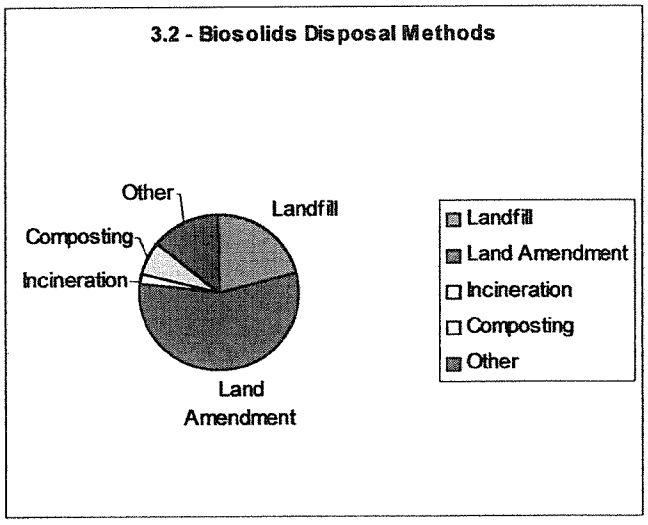
Question 3.1: How many biosolids disposal facilities does your system have?



3.1	# of Disposal Facilities	Response Quantity	Response Percentage
	0	18	24%
	1	38	51%
	2-5	14	19%
	6-10	3	4%
	11-15	0	0%
	16-20	1	1%
		74	100%
	Response Rate	61%	

75% of the respondents have one biosolids disposal facility or less.

Question 3.2: What is your biosolids disposal method?



3.2 Disposal Method	Response Quantity	Response Percentage
Landfill	21	28%
Land Amendment	54	71%
Incineration	2	3%
Composting	7	9%
Other	14	18%
	76 –> 98	129%
Response Rate	63%	

This question reveals that land amendment and landfill are the primary biosolids disposal methods. Respondents chose multiple methods in many cases. 98 responses were received from 76 respondents.

Question 3.3: What are your current sludge disposal costs ($ per dry ton)?

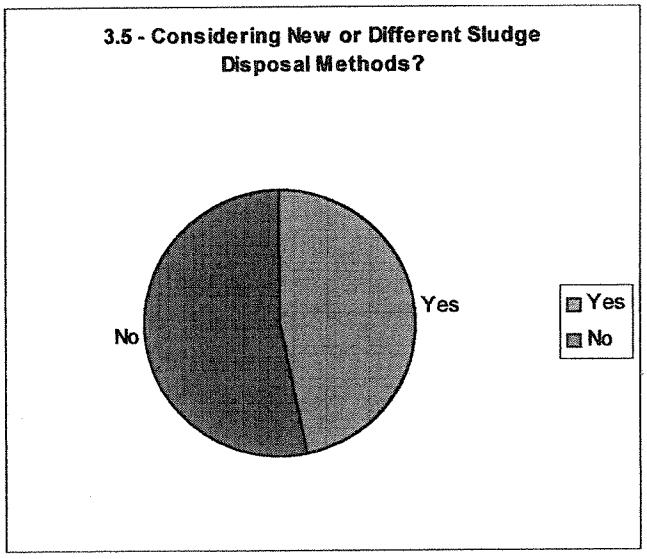
3.3 Sludge Disposal Costs	$ per Dry Ton
Average	114.07
Median	54
Range	0 to 547
Response Rate	54%

The complete results to Question 3.3 can be found in Appendix D. The open-ended nature of the question resulted in a low number of responses suitable for performing statistical calculations.

Question 3.4: What are the current landfill costs ($ per dry ton)?

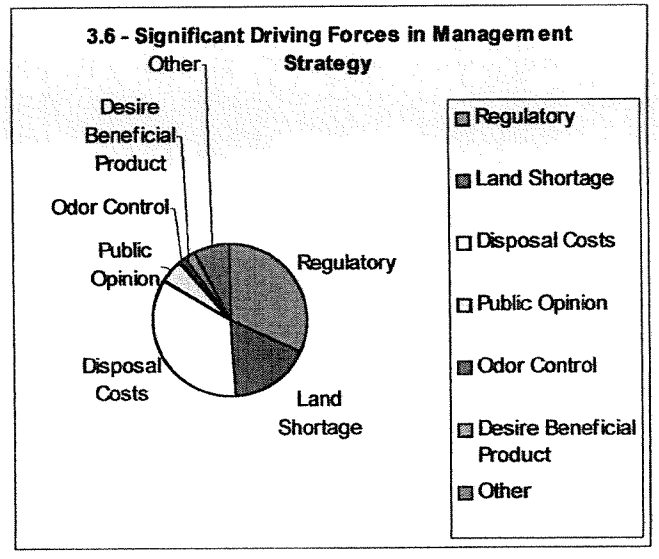
The results to Question 3.4 can be found in Appendix D. The open-ended nature of the question resulted in responses not suitable for performing statistical calculations.

Question 3.5: Are new or different sludge disposal methods being considered?



3.5	Considering Different Disposal Methods?	Response Quantity	Response Percentage
	Yes	34	47%
	No	39	53%
		73	100%
	Response Rate	60%	

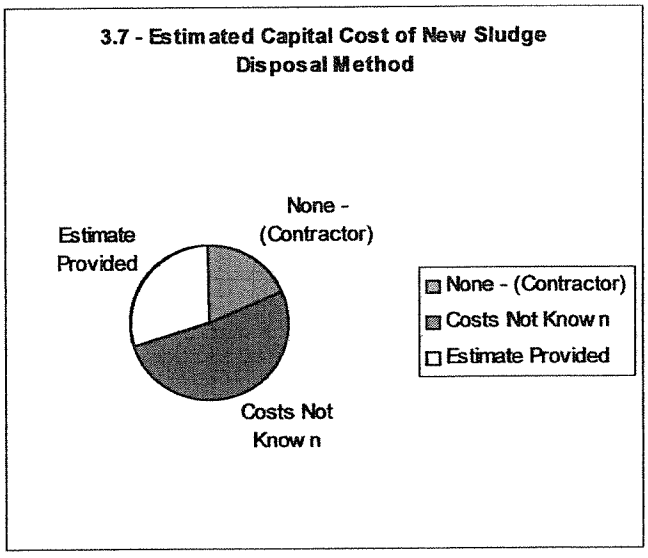
Question 3.6: What are the most significant driving forces in your sludge management strategy?



3.6	Strategic Driving Forces	Response Quantity	Response Percentage
	Regulatory	40	55%
	Land Shortage	21	29%
	Disposal Costs	44	60%
	Public Opinion	6	8%
	Odor Control	2	3%
	Desire Beneficial Product	3	4%
	Other	9	12%
		73 –>125	171%
	Response Rate	60%	

This question reveals that regulatory concerns and disposal costs are the primary driving forces in sludge management strategy. Land shortage is also highly apparent as is the "other" category, which is highly populated with concerns over public perception and acceptance. Respondents chose multiple methods in many cases. 125 responses were received from 73 respondents.

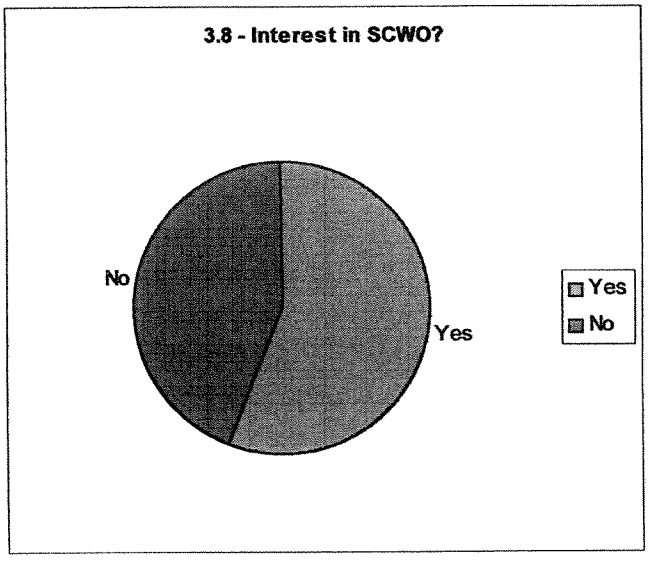
Question 3.7: If a new sludge disposal method is currently in consideration, what is the estimated capital cost?



3.7	Estimated Cost of New Method	Response Quantity	Response Percentage
	None - (Contractor)	10	19%
	Costs Not Known	27	51%
	Estimate Provided	16	30%
		53	100%
	Response Rate	44%	

The complete numerical results to Question 3.7 can be found in Appendix D. The open-ended nature of the question resulted in responses to projected costs not being suitable for performing statistical calculations.

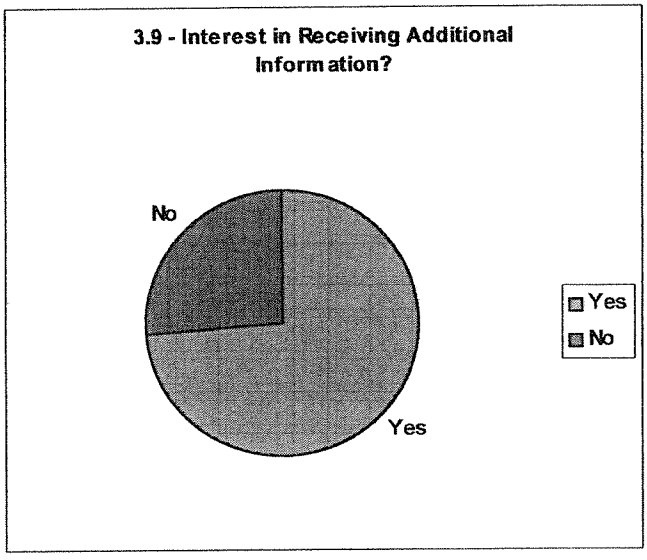
Question 3.8: Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?



3.8	SCWO Interest?	Response Quantity	Response Percentage
	Yes	39	56%
	No	31	44%
		70	100%
	Response Rate	58%	

Just over half of the respondents indicated that they were interested in SCWO.

Question 3.9: Do you want to receive additional information on this technology?



3.9	Desire Information?	Response Quantity	Response Percentage
	Yes	53	74%
	No	19	26%
		72	100%
	Response Rate	60%	

Nearly three-quarters of the respondents wanted more information.

Section 2 – Cross-Tabulated Results

The following table examines responses to Questions 1.3 in consideration of Question 3.5. The numbers indicate the average number of plants falling into the age range at the respondent's facility. It is notable that respondents considering new or different disposal methods have more plants over the age of 30 than do those not considering new methods. In comparison to the other age ranges, it can be concluded that facilities with plants older than 30 years are more interested than those with younger plants.

Table 1

	Question 3.5	
	Are new or different sludge disposal methods being considered?	
Question 1.3: How many plants are:	**Yes**	**No**
Less than 5 years old	0.8	0.8
5 to 15 years old	1.0	1.2
16 to 30 years old	2.2	2.4
Older than 30 years	1.3	0.9

The following table examines responses to Questions 1.3 in consideration of Question 3.8. The numbers indicate the average number of plants falling into the age range at the respondent's facility. The table indicates that facilities with younger plants are less likely to be interested in SCWO.

Table 2

	Question 3.8	
	Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?	
Question 1.3: How many plants are:	**Yes**	**No**
Less than 5 years old	0.6	1.0
5 to 15 years old	0.9	1.6
16 to 30 years old	2.1	2.7
Older than 30 years	1.2	0.9

The following table examines responses to Questions 1.4 in consideration of Question 3.5. The numbers indicate the number of respondents serving populations in the range provided. It is notable that larger populations are more likely than populations of less than 100,000 to be considering new or different sludge disposal methods.

Table 3

	Question 3.5	
	Are new or different sludge disposal methods being considered?	
Question 1.4: What is the overall population served:	**Yes**	**No**
Overall population: Less than 100,000	23	35
Overall population: 100,000 to 499,999	9	3
Overall population: 500,000 to 1,000,000	0	0
Overall population: More than 1,000,000	2	1

The following table examines responses to Questions 1.4 in consideration of Question 3.8. The numbers indicate the number of respondents serving populations in the range provided. It is notable that larger populations are more likely than populations of less than 100,000 to be interested in SCWO.

Table 4

	Question 3.8	
	Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?	
Question 1.4: What is the overall population served:	**Yes**	**No**
Overall population: Less than 100,000	29	26
Overall population: 100,000 to 499,999	8	4
Overall population: 500,000 to 1,000,000	0	0
Overall population: More than 1,000,000	2	1

The following table examines responses to Questions 1.10 in consideration of Question 3.5. The numbers indicate the number of respondents that finance capital improvements with the method indicated. It is notable that municipalities financing capital improvements through increased sewer rates are less likely to be considering new sludge disposal methods.

Table 5

	Question 3.5	
	Are new or different sludge disposal methods being considered?	
Question 1.10: How are capital improvement costs financed:	**Yes**	**No**
Capital improvement costs financed through: Municipal bonds	20	23
Capital improvement costs financed through: Increased sewer rates	18	26
Capital improvement costs financed through: Other	15	14

The following table examines responses to Questions 1.10 in consideration of Question 3.8. The numbers indicate the number of respondents that finance capital improvements with the method indicated. It is notable that municipalities financing capital improvements through increased sewer rates are more likely to be interested in SCWO. This is unexpected as this same group is less likely to be considering new methods for sludge disposal.

Table 6

	Question 3.8	
	Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?	
Question 1.10: How are capital improvement costs financed:	**Yes**	**No**
Capital improvement costs financed through: Municipal bonds	23	20
Capital improvement costs financed through: Increased sewer rates	26	15
Capital improvement costs financed through: Other	18	12

The following table examines responses to Questions 2.5 in consideration of Question 3.5. The number indicates the number of respondents that utilize the digester method indicated. It is notable that respondents utilizing tradition (listed) methods are more interested than those utilizing a different (specified other) response. The full list of responses for question 2.5 can be found in Appendix D.

Table 7

	Question 3.5	
	Are new or different sludge disposal methods being considered?	
Question 2.5: How is digester methane used:	**Yes**	**No**
Use digester methane for Digester Heating	19	14
Use digester methane for Power Generation	8	4
Use digester methane for Flare Gas	20	13
Use digester methane for Other purpose	6	16

The following table examines responses to Questions 2.5 in consideration of Question 3.8. The number indicates the number of respondents that utilize the digester method indicated. It is notable that respondents interest level in SCWO does not appear to correspond to method utilized.

Table 8

	Question 3.8	
	Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?	
Question 2.5: How is digester methane used:	**Yes**	**No**
Use digester methane for Digester Heating	25	7
Use digester methane for Power Generation	10	2
Use digester methane for Flare Gas	25	6
Use digester methane for Other purpose	12	8

The following table examines responses to Questions 2.6 in consideration of Question 3.5. The number indicates the respondents that operate their system with contractor, plant staff or other.

Table 9

Question 3.5
Are new or different sludge disposal methods being considered?

Question 2.6: If methane is used for power generation, is the system:	**Yes**	**No**
Operated by contractor	1	0
Operated by plant staff	11	4
Operated by Other	N/A	N/A

The following table examines responses to Questions 2.6 in consideration of Question 3.8. The number indicates the respondents that operate their system with contractor, plant staff or other.

Table 10

Question 3.8
Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?

Question 2.6: If methane is used for power generation, is the system:	**Yes**	**No**
Operated by contractor	1	0
Operated by plant staff	12	4
Operated by Other	N/A	N/A

The following table examines responses to Questions 3.2 in consideration of Question 3.5. The number indicates the respondents that utilize the biosolids disposal method listed. A complete list of specified other responses can be found in Appendix D. It is important to note that respondents utilizing land amendment are more likely to be considering new sludge disposal methods.

Table 11

	Question 3.5	
	Are new or different sludge disposal methods being considered?	
Question 3.2: What is your biosolids disposal method:	**Yes**	**No**
Biosolids disposal method: Landfill	5	10
Biosolids disposal method: Land amendment	28	23
Biosolids disposal method: Incineration	1	1
Biosolids disposal method: Other	8	17

The following table examines responses to Questions 3.2 in consideration of Question 3.8. The number indicates the respondents that utilize the biosolids disposal method listed. A complete list of specified other responses can be found in Appendix D. It is important to note that respondents utilizing land amendment and landfill are more likely to be interested in SCWO.

Table 12

	Question 3.8	
	Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?	
Question 3.2: What is your biosolids disposal method:	**Yes**	**No**
Biosolids disposal method: Landfill	9	6
Biosolids disposal method: Land amendment	33	14
Biosolids disposal method: Incineration	0	2
Biosolids disposal method: Other	10	16

The following table examines responses to Questions 3.6 in consideration of Question 3.5. The number indicates the respondents that believe the specified driving force is most significant in their sludge management strategy. It is important to note that managers with regulatory and other driving forces are more likely to be considering new sludge disposal methods.

Table 13

Question 3.5
Are new or different sludge disposal methods being considered?

Question 3.6: Most significant driving forces in sludge management strategy:	Yes	No
Regulatory	23	17
Land Shortage	11	9
Disposal Costs	20	23
Other	11	7

The following table examines responses to Questions 3.6 in consideration of Question 3.8. The number indicates the respondents that believe the specified driving force is most significant in their sludge management strategy. It is important to note that managers with land shortage and disposal costs as driving forces are more likely to be considering new sludge disposal methods.

Table 14

Question 3.8
Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation?

Question 3.6: Most significant driving forces in sludge management strategy:	Yes	No
Regulatory	20	18
Land Shortage	15	3
Disposal Costs	24	17
Other	11	8

Conclusions

The conclusions presented in this section address the items described in the problem statement by characterizing the state of the target market, identifying the driving forces in sludge management strategy, and judging the market potential for introducing SCWO. These key findings will allow General Atomics to further segment their target market and focus future efforts on the municipalities most likely to adopt SCWO.

At the outset of the project, General Atomics identified municipalities with wastewater treatment plants as the potential users of SCWO. Individuals responsible for treatment plants were polled via an online survey and additional insight regarding wastewater facilities was obtained. Specifically, respondents provided details about the composition and age of their facilities. The results from this initial section of the survey revealed that most facilities have less than five wastewater treatment plants in their organization and have been in use for more than 16 years. In fact, 21% of the plants represented in this survey have been in use for over 30 years. The large percentage of older facilities is a positive finding for General Atomics for two primary reasons. First, the respondents with plants that have been in use for over 30 years indicated that they are currently investigating new technologies to replace these older systems. Table 1 illustrates that facilities considering new or different sludge disposal methods tend to have a larger number of older plants in use. Second, the finding that 70% of these facilities are at least 16 years of age indicates that the likelihood of marketing SCWO as an upgrade is a feasible possibility.

Another notable result related to SCWO's target market is the indication by survey respondents that increased sewer rates and municipal bonds are often used for financing capital improvements. 76% of the respondents use one or both of these methods. This finding is an important one as both of these financing methods involve the public either directly or indirectly. Consequently, General Atomics should emphasize the features of SCWO that will be viewed positively by the public, such as the environmentally friendly aspects of the technology. Additionally, survey participants reinforced the assertion that General Atomics should highlight SCWO's politically

marketable features. 8% of the respondents manually entered "Public Opinion" as a significant driving force in their sludge management strategy.

By learning about the driving forces in sludge management strategy, General Atomics will be better equipped to address the needs of the customer. The survey results proved to be enlightening in this regard. The Public Works Directors taking part in this survey overwhelmingly identified regulatory issues and disposal costs as their two primary considerations. Land shortage was also considered an important driver in sludge management strategy. This finding is a positive result for General Atomics as the environmentally friendly nature of SCWO technology, its long-term financial benefits, and minimal land usage requirements will be powerful motivators for municipalities interested in upgrading their facilities.

Several criteria were used to evaluate the market potential for introducing SCWO to the wastewater treatment market. Consideration of new or different sludge disposal methods, interest in SCWO technology, and a desire to receive additional information were the primary indicators used to gauge market potential. Optimistic results were obtained in each of these areas. Specifically, 47% of all respondents indicated that new sludge disposal methods are being considered, while a sizable 73% of the respondents serving populations of 100,000 or greater are considering new methods. The results indicating interest in SCWO technology is even more encouraging. 56% of all respondents had interest or potential use for this advanced sludge process and 74% of the respondents want to receive additional information on this technology. These criteria, and the key findings already discussed, lead us to the conclusion that demand exists for an innovative wastewater treatment technology, and SCWO has the potential to satisfy this demand.

In addition to addressing the issues outlined in the problem statement, characteristics that were consistent with respondents interested in SCWO or considering new technologies were also identified. These findings will assist General Atomics in further segmenting the wastewater treatment market. According to the survey results, target treatment facilities would ideally have the following characteristics:

- Possess plants that are older than 30 years
- Serve populations of 100,000 to 499,999 and over 1,000,000
- Use gravity belts or centrifuge for biosolids dewatering
- Utilize greater than 5 personnel at each bioprocessing plant (on average)
- Utilize landfill or land amendment as biosolids disposal method
- Have regulatory concerns and disposal costs as their most significant driving forces in sludge management strategy.

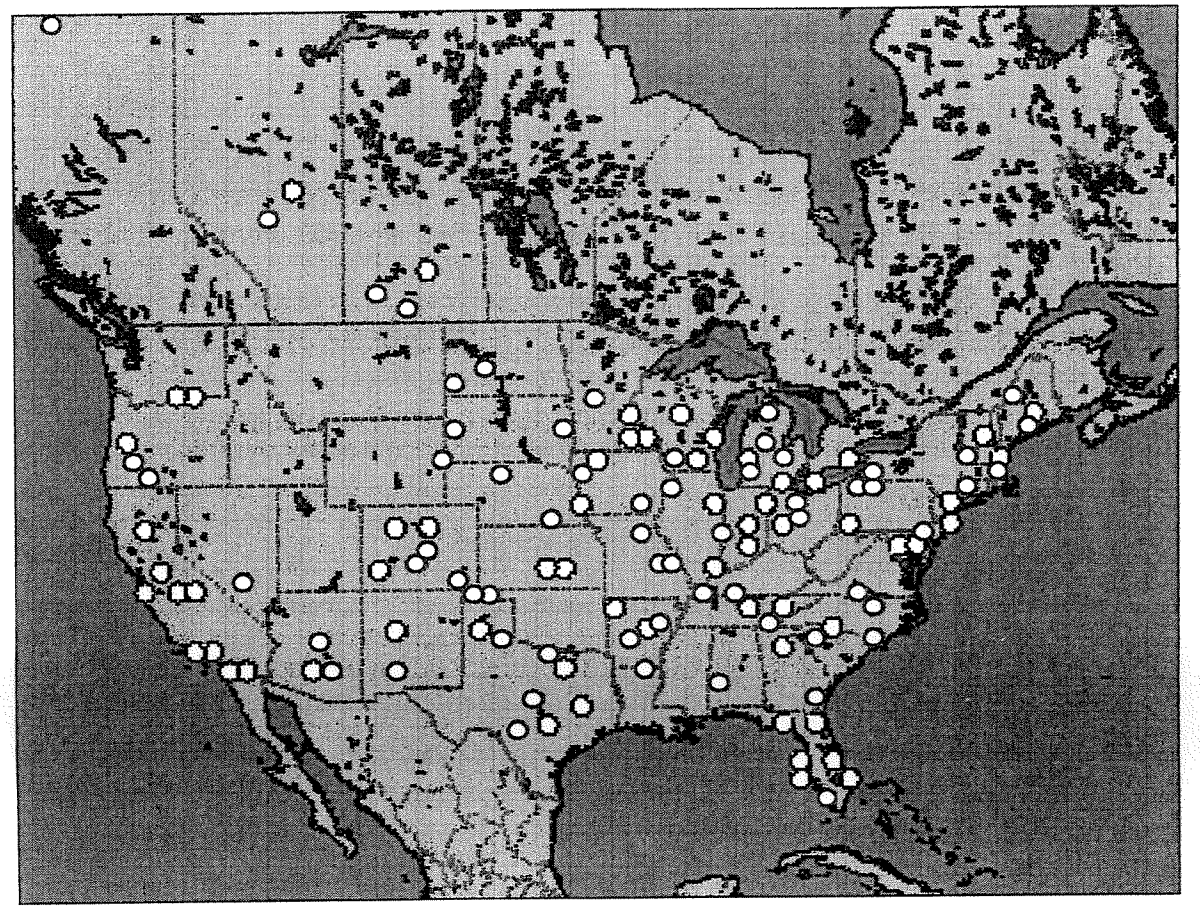
Recommendations

The following recommendations are intended to assist General Atomics in addressing the municipal wastewater treatment market.

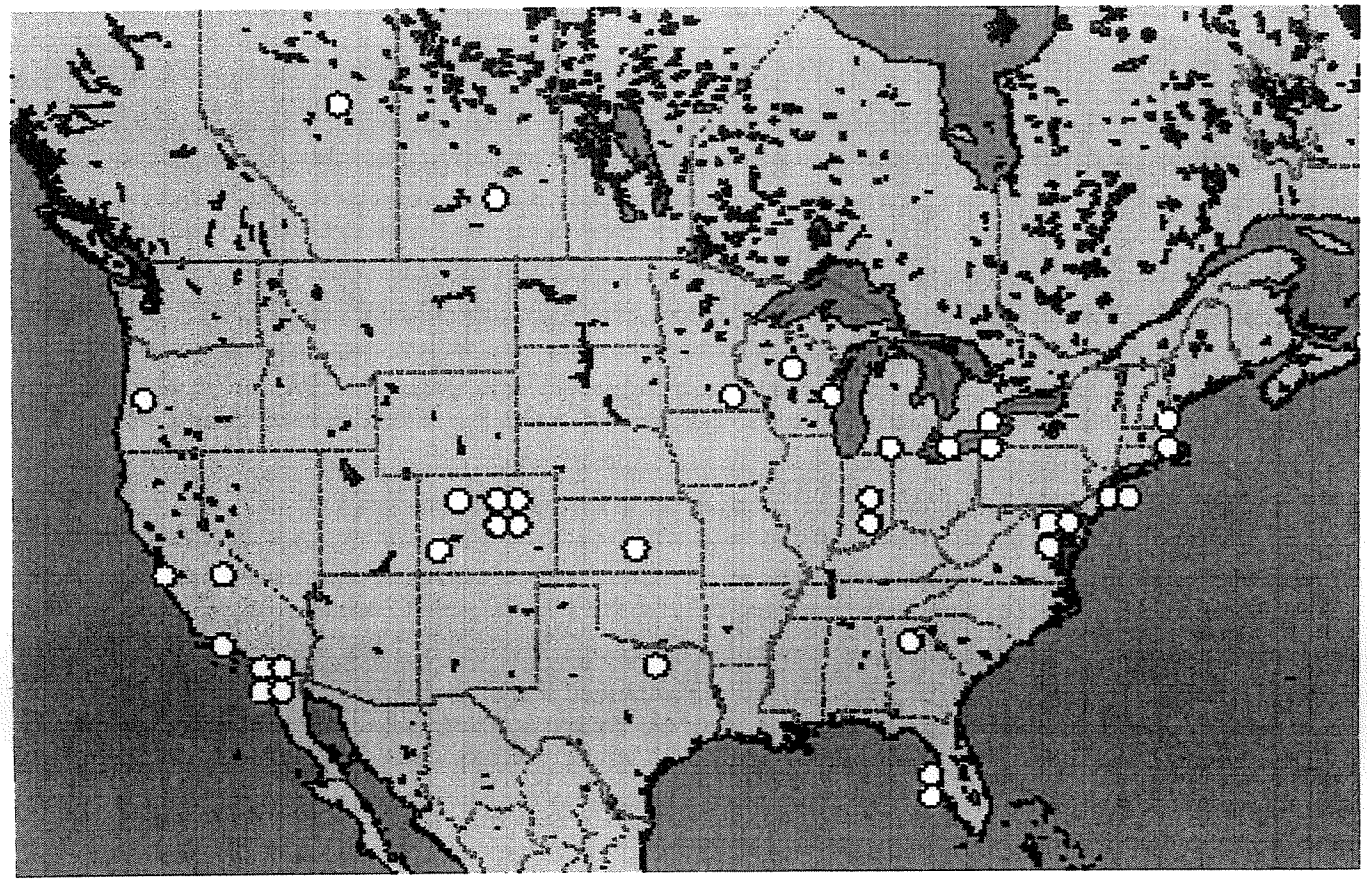
- First, General Atomics should identify target municipalities using the characteristics outlined in the previous section. This will allow General Atomics to focus future efforts on the municipalities most likely to adopt SCWO. The survey respondents that match this description have already been e-mailed and encouraged to contact General Atomics directly for more information regarding SCWO technology.
- Second, General Atomics should begin educating the wastewater treatment market, specifically Public Works Directors, about the benefits of SCWO, particularly with regard to environmental and financial factors. For example, General Atomics should consider setting up a booth to disseminate SCWO brochures and answer questions at the International Public Works Congress & Exposition. The annual Congress attracts over 5000 public works professionals from both public and private sectors and includes representatives from all across the United States and over 14 international countries.
- Third, General Atomics should use an alternative method for identifying potential customers. The current method, as directed by General Atomics, was to sort respondents based on interest in SCWO or potential use for an advanced sludge disposal process. Unfortunately, survey results showed several respondents listed themselves as "uninterested," even though their responses reveal that they might benefit greatly from SCWO. This finding indicates that a portion of the market could be identified through different sorting criteria. Additionally, interest in the technology could be generated through increased awareness and education.
- Finally, General Atomics should further analyze the raw data collected for this study. The open-ended questions were not ideal for statistical analysis, but did provide additional information and insight that could prove to be useful.

APPENDIX A - Maps of Respondents

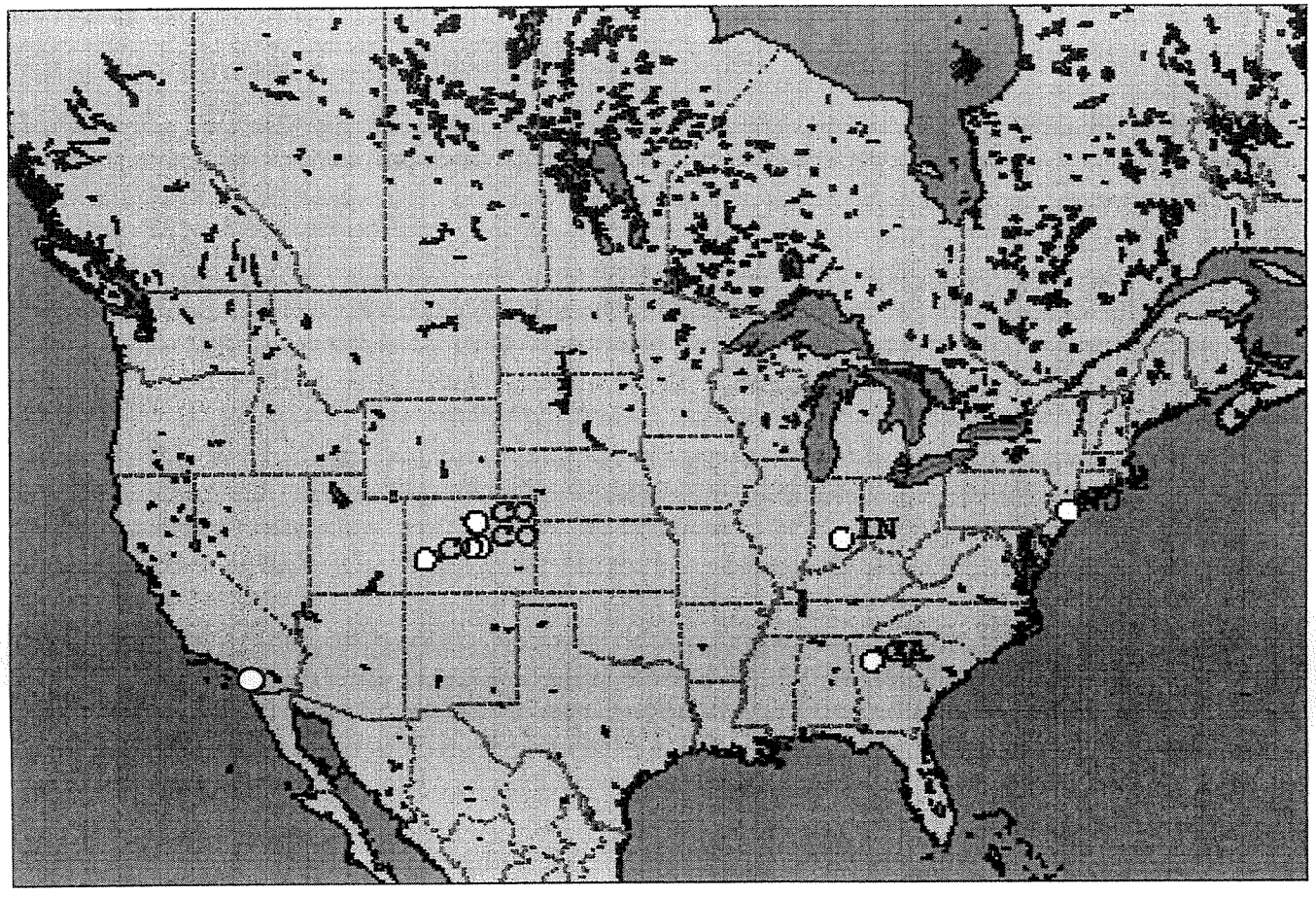
121 Survey Respondents from US and Canada



37 SCWO Interested Respondents



Final 7 Respondents



APPENDIX B – E-mail Correspondence

Dear [Name of the Director of Public Works]

The San Diego State University Business Alliance requests participation of your organization in a Biosolids Processing and Disposal Survey developed for the purpose of evaluating an alternative technology to current biosolids disposal options.

Biosolids disposal is becoming more difficult every year as new ordinances and laws restrict land placement. Treating biosolids in-house with a new technology called SCWO is an economical and environmentally friendly option. SCWO stands for Supercritical Water Oxidation. Residual solids from SCWO are clean and inert. Energy can be recovered from a SCWO system as steam or hot-water, and other by-products (carbon dioxide, minerals) can be considered for recovery and resale.

This national survey, subsequent analysis, and reporting will comprise the MBA thesis project for a team of graduate students. The results of the survey will be shared with the participating wastewater treatment organizations, giving them valuable nationwide industry data on biosolids processing.

To ensure that the survey results accurately reflect future wastewater management challenges and decisions, we request that the survey be completed by the Municipal Wastewater Department Director (or equivalent) of your organization. If necessary, please forward this message to the appropriate person.

Your participation is very much appreciated. If you have any questions about the survey, please feel free to contact our San Diego State University faculty advisor, Dr Donald Sciglimpaglia at dsciglim@mail.sdsu.edu

A web link to the survey is attached below; please click on the link to launch the survey:
http://www.surveymonkey.com/s.asp?A=1605721E2817

Sincerely,

Business Project Consulting Team
College of Business Administration
San Diego State University

Dear [Name of the Director of Public Works]

Please accept our kind reminder to participate in the ongoing San Diego State University Biosolids Survey, developed for the purpose of evaluating an alternative technology to current biosolids disposal options.

This national survey, subsequent analysis, and reporting will comprise the MBA thesis project for a team of graduate San Diego State University students. Your organization's participation is a valuable component in our project. The results of the survey will be shared with the participating wastewater treatment organizations, giving them valuable nationwide industry data on biosolids processing.

If necessary, please forward this message to the appropriate (Municipal Wastewater Department Director or equivalent) person, who can help us by filling out the survey.

A web link to the survey is attached below; please click on the link to launch the survey:
http://www.surveymonkey.com/s.asp?A=1676754E4941

Sincerely,

Business Project Consulting Team
College of Business Administration
San Diego State University

To : SCWO Survey Respondent

From : The Student Team at SDSU
Subject: Results of San Diego State University Biosolids Survey

Hello again, and thank you for your assistance in gathering a massive amount of data from across the continent. We were overwhelmed by your responses and appreciate the valuable time you have taken to fill out the requested information.

As promised, you will find an attachment to this letter with our collected data (with sensitive contact data omitted). We hope that you find it as interesting as we did to see current trends in Biosolids Disposal.

This will conclude the series of contacts necessary to complete our project and we would like to again assure you that your anonymity has been protected. If you have any further questions regarding the SCWO technology we have been discussing, please contact the person listed in the information below.

Carol.smith@gat.com
phone# (858) 455-2542

Very respectfully,

Business Project Consulting Team
College of Business Administration
San Diego State University

APPENDIX C - Biosolids Processing and Disposal Survey

The San Diego State University Business Alliance greatly appreciates your participation in this Biosolids Processing and Disposal Survey developed for the purpose of evaluating an alternative technology to current biosolids disposal options.

The survey is structured to obtain relevant information in the following three areas of interest:

1) Wastewater facilities information
2) Biosolids processing information
3) Biosolids disposal information

The survey, subsequent analysis, and reporting will comprise the MBA thesis project for a team of SDSU graduate students.

Upon completion of the analysis, the survey results will be shared with you, giving you valuable industry data on biosolids processing.

Click "Next" to get started with the survey.

1.0 WASTEWATER TREATMENT FACILITIES:

1.1 How many wastewater treatment plants are in your organization? [ ]

1.2 How many treatment plants are primary treatment only [ ]? primary & secondary treatment [ ]?

1.3 How many plants are less than 5 years old [ ]; 5 – 15 years old [ ]; 15 – 30 years [ ]; older than 30 years [ ].

1.4 What is the overall population served: [ ] less than 100,000; [ ] 100,000 – 500,000; [ ] 500,000 – 1,000,000; [ ] more than 1,000,000.

1.5 What is the total treatment capacity: [ ] millions gallons per day through a total of [ ] separate plants.

1.6 What is the total biosolids capacity of all plants: [ ] dry tons sludge per day.

1.7 What is the planned capacity next 5-10 years: [ ] dry tons sludge per day.

1.8 What is the planned capacity next 10 – 20 years: [ ] dry tons per day.

1.9 What are the current sewer rate charges: residential [$] per hundred cubic feet; commercial [$] per hundred cubic feet.

1.10 How are capital improvement costs financed: [ ] municipal bonds; [ ] increased sewer rates; [ ] other; please specify: [ ].

2.0 BIOSOLIDS PROCESSING:

Supercritical water oxidation (SCWO) can be used to destroy biosolids and extract useful heat and other products. The system can take sludge upstream of bio digesters or following; whichever is better for the plant. Upstream is preferred because it eliminates the need for digesters and provides a more useful stream for SCWO.

2.1 How many treatment plants use the following types of biosolids? dewatering [ ] belt filters, [ ] gravity belts, [ ] centrifuge [ ] other, please specify [ ]

2.2 What solids levels are currently attained? (in %) [ ]

2.3 How many operations & maintenance personnel are assigned to bio processing at each plant? Plant 1 [ ]; Plant 2 [ ]; Plant 3 [ ]; Plant 4 [ ]; Other plants, please specify [ ]

2.4 Are the plants staffed on a 24/7 basis? [ ] Yes; [ ] No.

2.5 How is digester methane used: [ ] digester heating; [ ] power generation; [ ] gas is flared; [ ] other; please specify: [ ].

2.6 If methane is used for power generation, is the system: [ ] contractor operated; [ ] operated by plant staff; [ ] other, please specify: [ ].

2.7 Are there near-by industrial neighbors who might be able to use plant steam, power, CO2 or other products from the wastewater treatment plant? [ ] yes; [ ] no

3.0 BIOSOLIDS DISPOSAL PROCESS:

The simplest way to incorporate supercritical water oxidation into a facility is as an add-on at the end of the process. Instead of burning biosolids or shipping to land amendment or other facilities the bio slurry could be directly processed by SCWO.

3.1 How many biosolids disposal facilities does your system have? [ ].

3.2 What is your biosolids disposal method: [ ] land fill; [ ] land amendment; [ ] incineration; [ ] other, please specify: [ ].

3.3 What are your current sludge disposal costs: [$] per dry ton.

3.4 What are the current landfill costs (based on dry tons)? [ ]

3.5 Are new or different sludge disposal methods being considered: [ ] yes, [ ] no

3.6 What are the most significant driving forces in your sludge management strategy? [ ] regulatory; [ ] land shortage; [ ] disposal costs; [ ] other.

3.7 If a new sludge disposal method is currently in consideration, what is the estimated capital cost? [ ] none (disposal by contractor); [$]; not known [ ].

3.8 Do you have any interest or potential use for an advanced sludge disposal process called supercritical water oxidation? [ ] Yes [ ] No.

3.9 Do you want to receive additional information on this technology? [ ] Yes [ ] No

Thank you for completing the survey!!!

Upon completion of the analysis, the survey results will be shared with you, giving you valuable industry data on biosolids processing. The results will help you in your future wastewater management planning needs.

What is your postal zip-code? (This will help us categorize the data) [ ]

Please provide your e-mail address, so that we can send you a copy of the final report. [ ]

Best Regards,

SDSU MBA Project Consulting Team

APPENDIX D - Selected Open-Ended Questions

1.9 What are the current sewer rate charges:

Residential ($ per hundred cubic feet)
based on water use
126 % of water declining tier.
159%
$7.50
Rate based on flow. Multi tiered rates
0.19 (Canadian)
16
$1.77
base rate: $4.28 + $1.347/100 cubic feet
$2.38
Cdn$1.07 (transmission & treatment only)
$1.74
1.45 per 1000 gals
$2.26
Operation $2.24 Capital $3.50
1.65
12.00 per month flat rate
$10.92 + 2.15 / 1k gal. Based on water use up to 12k gallons.
Flat rate of $16/Month/Residential Dwelling
$0.33
157% of Water Bill
$12.40 per month
$3.88 per 000 gallons
$22.00/month
$0.02
$4.20/1000 igals water and sewer
1.29
3.63
0.376
2.28
NA
$ 1.47/1000 gals
2
$2.14/ccf
2
0.0216
24.47
0.196
1.74
US$0.62/100cu.ft. after 70 982cu.ft. US$0.23/100cu.ft.
3.66/1000 gals.
flat rate single family - $21.08 mobile home $7.19 du/triplex 16.17 condo $8.05 multiple family res.
$11.35
$3.90 per thousand Gallons

$ 3.28 + Base fee $ 9.43
0.2057
$6.00 base + $1.25/thousand
1.22
0.5
Scale is: 6.70 for 1st 2000 gal 3.95 for next 8 000 gal and 4.80 for next 10 000 & up.
NA
$21.20 per month flat rate
$1.88
$255.97/single family home
1.36
3.21
1.33
NA
1.87
$18.55 flat/unit
2.40/1k gallons
1.21

3.3 What are your current sludge disposal costs ($ per dry ton)?
approx $36.00 (not including labor)
29.00 / wet ton
250
Don't know
$0.16399/1 000 gallons
$60 (Canadian)
N/A
7.50 (land application costs only)
$150
Cdn$170
$160 / ton
150
$10 per dry ton
12
120
$51.61/CY
160
$547 00 per dry ton
16
0
Land Application - $20/dry T;
Composting - $40/dry T net
$18.00
N/A
treatment costs @$70/ton
$37.00 per 000 gallons - centrifuged

$210.00
approx $120.00 cdn/ton
30
300
650.00 for annual analysis
21
$108.15
12.45
$44.66/dt
175
24
240
$12
30
unknown
US$4.80/ton(US)
7.00/cubic yard
$28-$31
$21.00 per ton
$100.00
$250
275
est. $54/dry ton
0.002
115
278
$186
350
$200 (estimate)
$0.00 Using on site disposal acerage at this time.
$300
neglegable
125
28
$50 to $55
429
260
$25.00
$193.00
36

3.4 What are the current landfill costs ($ per dry ton)?
$25.00
40.00 / wet ton

Don't know
18.5
$24
N/A
47
NA
n/a
$130 / ton
N/a
N/A
n/a
N/A
None
n/a
N/A
30
0
$100/dry T
$31.66
N/A
$30.00
0
$28.00
$400.00
0
13.5
16
N/A
N/A
$150.00/dt
na
117.5
$42
200
35
unknown
US$27/ton(US)
0
$44
$100.00
Depends on landfill $13 to $27/ton not dry ton
0
???
168

Unknown we have not sent sent sewage sludge to the landfill since 1992. We were the 1st city in Arkansas to be permitted to give finished compost back to the residents.

$235

Ash & grit to landfill @ $45/ton

$4.25

0

0

NA

NA

0

N/A

N/A

n/a

3.7 If a new sludge disposal method is currently in consideration what is the estimated capital cost?

5 million

$100 000.00

n/A

2 000 000

n/a

$1 208 243 for construction of facility.

1 000 000

$450 000

1000000

$250 000.00

NA

N/A

$8 Million

15 000 000

1.2 million

$5 916 000

APPENDIX E - Service Agreement with surveymonkey.com

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APPENDIX F – References

References

Brennan, Pat. "Sewage Treatment on Tap," *The Orange County Register*. Sunday, July 14, 2002. News 1, 25.

Market data reproduced from the report by Dun & Bradstreet Sales & Marketing Solutions provided by http://www.zapdata.com

Market situation information gathered from the following resources:

- http://www.apwa.net/ResourceCenter/
- http://www.swana.org
- http://www.wef.org/
- http://www.hydroprocessing.com