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Ministry of Water and Irrigation

# Water Quality Improvement and Conservation Project

## Feasibility Study:

## Sulpho-Chemicals Company

Report 3114-95 2b-44

Science Applications International Corp

Development Alternatives Inc

The Technical Assistance Team Includes

**Development Alternatives, Inc**
Science Applications International Corp
Harza Environmental Services, Inc
Development Associates, Inc

USAID

United States Agency for International Development
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# SULFUR CHEMICALS INDUSTRY FEASIBILITY STUDY JORDAN SULPHO-CHEMICALS COMPANY JORDAN

PRE-FINAL REPORT

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Submitted by

Development Alternatives, Inc

Prepared by

Science Applications International Corp (SAIC)
McLean, VA, USA

and

Harza Consulting Engineers and Scientists
Chicago, IL, USA

in association with

Royal Scientific Society (RSS)
Amman, Jordan

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## PREFACE/ACKNOWLEDGMENTS

This report is the result of a feasibility study performed for the Jordan Sulpho-Chemicals Company in Jordan The purpose of the study was to evaluate technical and economical feasibilities of the pollution prevention/waste minimization (PP/WM) and water conservation techniques recommended in audit report #3114-94-2b-10, dated December 1994

Several individuals on the Water Quality Improvement and Conservation Project contributed to this report Dr Usama Mudallal of the Amman Chamber of Industry (Chamber) Engineer Rania Abdel Khaleq of the Ministry of Water and Irrigation (MWI),, and Dr Omar Jabay and Eng Hashim Beano of the Royal Scientific Society of Amman, plant managerial and technical staff including Mr Hatem Abbas, technical manager and Mr Said Abdullah, shared their knowledge with Mr David Hair , of Science Applications International Corporation (SAIC) McLean, Virginia, USA. These technical staff worked under the direction of Dr Shawn R Niaki, P E , Pollution Prevention Program Director, of Harza Consulting Engineers and Scientists, Chicago, Illinois, USA, who heads the WQIC component under which the study was housed It is from their combined expertise that this report was possible

Special appreciation is given to Dr Mohammed Bani Hani, Secretary General of MWI Eng Koussai Quteishat, Secretary General of the Water Authority of Jordan (WAJ) Mr Khaldun Abuhassan, Chairman of the Chamber; Mr Walid Al-Khathib, Director General of the Chamber, Dr Muwaffaq Saqqar, Project Coordinator from MWI,, the members of the PP/WM working group from WAJ including Eng Abdul Wahab Matar Eng Marwan Al-Tal Eng Nabeel Hejazeen, Eng Mohamad Lafi, and to Development Alternatives, Inc as represented by Edwin D Stains, Chief of Party, for their cooperation and confidence

# EXECUTIVE SUMMARY

Under Contract No 278-0288-00-4026-00 with the United States Agency for International Development (USAID) Development Alternatives, Inc (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber)

The IWDP is being performed in three phases The first phase required completion of ten pollution prevention/waste minimization (PP/WM) audits by DAI and its sub-contractors The second phase requires completion of Feasibility Studies (FS) for four of the audited facilities Finally, demonstration projects will be completed for two selected Feasibility Study (FS) facilities This report presents the findings of the FS conducted to evaluate the feasibility of the PP/WM and water conservation opportunities identified during the 1994 PP/WM Audit of the Jordan Sulpho-Chemicals Company (JSC) facility

Harza Consulting Engineers and Scientists (Harza), Chicago, Illinois, USA, and Science Applications International Corporation (SAIC), McLean, Virginia, USA, have been retained as the subcontractors to lead the audits and feasibility studies The Royal Scientific Society (RSS) of Jordan, was selected as the local consultant to assist the lead consultants in the conduct of the audits and studies, and in report development The PP/WM audit and the feasibility study for the JSC facility was conducted by the SAIC/RSS team

## Pollution Prevention/Waste Minimization Audit Findings

The "Sulfur Chemicals Industry Audit Report, Jordan Sulpho-Chemicals Company, Jordan" (USAID 1994) presented the findings of the audit conducted at the Jordan Sulpho-Chemicals Company (JSC) facility on September 20, 1994, and the results of the subsequent discharge monitoring conducted by the audit team on September 25, 1994 The report provided recommendations for the development of a site-specific program to meet the specific needs and goals of the JSC facility Audit recommendations included both PP/WM techniques (e g , water conservation techniques, housekeeping practices, alternate waste disposal practices, etc ) and suggestions for PP/WM training for facility staff and follow-up studies to assess program successes A brief overview of the findings presented in the PP/WM audit report is provided below

### Water Use and Balance

JSC's total water requirement was dependent on whether water was supplied by tanker or drawn from JSC's private well Where water was received from tankers, the facility required approximately 90 cubic meters ($m^3$) per day of fresh water for all uses except potable water When the reverse osmosis (RO) unit was in operation, the facility water use increased to approximately 110 $m^3$/day due to the RO reject and membrane washing streams



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During the audit, JSC staff assisted the audit team in developing an water balance for each of the plant processes The water balance, was incorporated on to facility process diagrams, and identified all major water uses and discharges Based on the evaluation of current water use and disposal practices, the audit team determined that the primary water uses at the JSC facility were for non-contact cooling of process reactors and for contact cooling and dissolution during sodium silicate production The audit determined that the JSC facility's water use practices were generally conservative, however, several water conservation opportunities were identified

**Wastewater Discharges**

All routine discharges of process wastewater from the JSC facility were collected and directed to the central wastewater collection basin Discharges to the basin included all process wastestreams, cooling water system blowdown, boiler blowdown, cleaning and maintenance discharges, and leaks and spills within the plant processing areas The waste collection basin reportedly has no effluent discharge to the wadi or groundwater, however, its proper operation and maintenance are imperative for protecting local surface and groundwater resources

While all plant wastestreams flow to the collection basin during normal operations, the facility reported that in wet weather, all process and storm water flows are directed directly to the wadi Based on general drainage characteristics of the facility, many of the areas where solid and liquid wastes are stored would also drain directly to the wadi

Based on the audit findings, the audit team developed a series of recommendations to minimize wastewater generation at the JSC facility The audit team's recommendations included PP/WM opportunities in the following categories modifications to production processes and schedules, raw materials substitution, cooling water segregation and reuse, spill and leak prevention, and, collection and reuse/recycling of off-spec materials and waste products

**Air Emissions and Solid Wastes**

While the focus of the PP/WM and water conservation audit was related to water use and wastewater generation, the solid wastes generated, and the pollutants discharged to the atmosphere were also examined With respect to solid wastes, the audit team determined that the JSC facility s raw material and waste handling practices would likely contribute significant pollutant loadings to the waste collection basin and storm water runoff to the wadi

## Feasibility Study Process

The feasibility study was conducted in three phases The first phase included a technical evaluation of the engineering feasibility of each of the PP/WM and water conservation opportunities identified during the audit The second phase analyzed the cost to develop and implement each of the opportunities and evaluated the benefit(s) of implementing the alternatives The third phase compared the findings of the technical evaluation and the cost/benefit analysis

and provided recommendations as to which of the proposed PP/WM and water conservation alternative(s) were most appropriate for the JSC facility

## Technical Feasibility Evaluation

The technical feasibility of each of the PP/WM and water conservation opportunities was evaluated to determine whether the proposed alternative was possible based on available technology In addition, the technical feasibility evaluation considered site-specific constraints at the JSC facility For most of the identified alternatives, the evaluation did not require engineering plans or specifications However, where detailed evaluations were required, preliminary engineering plans and specifications were outlined by the lead technical contractor (SAIC) and prepared in Jordan by the Royal Scientific Society (RSS) counterpart

### Pollution Prevention/Waste Minimization Techniques

During the audit of the JSC facility, the audit team identified a variety of PP/WM opportunities related to the facilities current wastewater generation and disposal practices While the focus of the audit was on PP/WM activities related to wastewater discharges, several opportunities related to air emissions and solid wastes were also identified In particular, the audit team identified potential opportunities to reduce loadings from the facility to the collection basin and, under storm conditions, to the wadi Based on the evaluation, the audit team determined that several of the PP/WM techniques could result in the recovery of useful materials by the JSC facility

In general, the PP/WM opportunities identified for the JSC facility could be arranged in three general categories

- Process Control,
- Materials Handling and Storage, and
- Control of Other Waste Generating Activities

The results of the technical feasibility evaluation for each of these categories of PP/WM opportunities is summarized in Tables 1 through 3

### Water Conservation Techniques

Water conservation is an extremely important concern in the Zarqa Basin, and throughout Jordan Therefore, during the facility audit, special attention was paid to water use practices The audit revealed that JSC facility's water use practices were generally conservative due to the relatively high cost and limited supply of clean water Several additional conservation techniques, however, were identified by the audit team

In order to optimize its use of water resources, the audit team recommended that the JSC facility carefully monitor flows and uses within facility operations and develop a written strategy to coordinate water conservation activities While water conservation is an important concern, the use of water at the JSC facility is necessary for the production of a high quality product The water conservation opportunities were, therefore, evaluated to assess possible adverse impacts on production processes

In general, the opportunities for water conservation identified for the JSC facility could be arranged in three general categories

- Process Control,
- Cooling and Boiler Water, and
- Floor Wash and Cleaning Activities

The results of the technical feasibility evaluation for each of these categories of water conservation opportunities is summarized in Tables 4 through 6

## Opportunity Cost/Benefit Analysis

Following the development of technical feasibility evaluation for each of the PP/WM and water conservation opportunities, cost estimates were developed by the in-country contractor (RSS) The costs included only capital costs necessary to implement and operate each of the proposed activities The results of the cost evaluation were then compared to the environmental benefit(s) that were established during the PP/WM audit In many cases, quantification of the costs and benefits was not possible due to data gaps and other uncertainties In these instances, a qualitative assessment was provided The results of the cost benefit analysis are provided in Tables 1 through 6

## Conclusions and Recommendations

Based on the technical feasibility evaluation and the cost benefit analysis, the audit team provided recommendations for each of the PP/WM and water conservation opportunities In general, if the alternative was both technically feasible and cost effective, the alternative was recommended

Subsequent to the facility audit, the JSC facility reviewed the preliminary PP/WM and water conservation recommendations and provided comments to the audit team In its comments, the JSC facility reported that several of the recommended alternatives had already been implemented, and that plans were under development for several others

The findings and recommendations are summarized in tabular form, and identified whether the alterative was "technically feasible," "cost effective," and whether or not it is recommended by the FS team as a viable alternative In addition, the alternatives that JSC reported as implemented, or under development, are indicated in the tables by the shaded cells

### Recommendations for Pollution Prevention/Waste Minimization Techniques

The conclusions and recommendations regarding PP/WM alternatives are provided in Tables 1, 2, and 3



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| Table 1 - Evaluation of Process Control PP/WM Opportunities* | | | |
|---|---|---|---|
| **Process Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Sulfonation/Sulfation | | | |
| Reduction in Use of Branched Alkylbenzene | Yes | Yes | Yes |
| Sulfonator Optimization | No | N/A | No |
| Utilization of Sealless Pump | Yes | Yes | Yes |
| Leak Control | Yes | Yes | Yes |
| Spill Prevention | Yes | Yes | Yes |
| Sulfur Quality Control | Yes | No | No |
| Catalytic Converter Optimization | Yes | Unknown | Yes |
| Saponification | | | |
| Reactor Optimization | No | N/A | No |
| Leak Control | Yes | Yes | Yes |
| Production Schedule Optimization | No | N/A | No |
| Sodium Silicate Production | | | |
| Elimination or Minimization of Contact Cooling | Yes | Yes | Yes |
| Sediment/Filter Solids Control | Yes | Yes | Yes |
| - Increasing the purity of raw materials | Yes | Yes | Yes |
| - Optimizing the operation of the kiln | Yes | Yes | Yes |
| - Optimizing the dissolving conditions in the autoclave | Yes | Yes | Yes |
| Dust Control | Yes | Yes | Yes |
| Sodium Toluene Sulfonate Production | | | |
| Elimination of Toluene Discharge | Yes | Yes | Yes |
| STS Cooling Water Segregation | No | N/A | No |
| Leak Control | Yes | Yes | Yes |
| Alkanolamides Production | | | |
| Drum all pasty wastes | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented, or has begun to implement the alternative

| Table 2 - Evaluation of Materials Handling and Storage PP/WM Opportunities* | | | |
|---|---|---|---|
| **Materials Handling and Storage Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Containment of loading and unloading areas | Yes | Yes | Yes |
| Containment of storage areas | Yes | Yes | Yes |
| Elimination of drainage hole in sulfur melting room and clean-up of solid waste | Yes | Yes | Yes |
| Dry clean-up of leaks and spills and maintenance of overflow collectors | Yes | Yes | Yes |
| Maintenance and operation of existing containment structures | Yes | Yes | Yes |
| Elimination of tanker truck and barrel washing | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement the alternative

| Table 3 - Evaluation of PP/WM Opportunities for Control of Other Waste Generating Activities* | | | |
|---|---|---|---|
| **Other Waste Generation Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Solid and Drummed Wastes | | | |
| Utilization of Sulfur Wastes | Yes | Yes | Yes |
| Utilization of Charred Material | Yes | Yes | Yes |
| Utilization of Sodium Silicate Sediment | Yes | Yes | Yes |
| Utilization of Sodium Sulfate Wastes | Yes | Yes | Yes |
| Utilities Wastes | | | |
| Utilization of RO Reject | N/A | N/A | N/A |
| Utilization of Recovered Fuel Oil | Yes | Yes | Yes |
| Leak and Spill Prevention | Yes | Yes | Yes |
| Domestic Waste Treatment | N/A | N/A | N/A |
| Waste Collection Basin | | | |
| Optimize Operation of the Collection Basin | Yes | Yes | Yes |
| Prevent Seepage from the Collection Basin | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement the alternative

## Recommendations for Water Conservation Techniques

The conclusions and recommendations regarding water conservation alternatives are provided in Tables 4, 5, and 6

| Table 4 - Evaluation of Water Conservation Opportunities for Process Control* | | | |
|---|---|---|---|
| **Process Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Sulfonation/Sulfation | | | |
| Leak Prevention | Yes | Yes | Yes |
| Elimination of Contact Cooling for Sulfur Pumps | Yes | Yes | Yes |
| Minimization of Scrubber Water | Yes | Unknown | Yes |
| Saponification | | | |
| Leak Prevention/Condensate Reuse | Yes | Yes | Yes |
| Sodium Silicate Production | | | |
| Minimization of Contact Cooling for Casting Belt | Yes | Yes | Yes |
| Maximization of Cooling Water Reuse | Yes | Yes | Yes |
| STS Production | | | |
| Process Water Reuse | Yes | Yes | Yes |
| Cooling Water Segregation | No | N/A | No |
| Dryer Condensate Reuse | Yes | Unknown | Yes |

* Shaded cell indicates that JSC has already implemented, or has begun to implement, the alternative

| Table 5 - Evaluation Water Conservation Opportunities for Cooling and Boiler Water* | | | |
|---|---|---|---|
| **Cooling and Boiler Water Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Pre-treatment of Cooling Water | N/A | N/A | N/A |
| Maximization of Heat Recovery | Yes | Unknown | Yes |
| Reduction of Steam Losses | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement the alternative

| Table 6 - Evaluation of Water Conservation Opportunities for Floor Wash and Cleaning Activities* | | | |
|---|---|---|---|
| **Floor Wash and Cleaning Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Floor Washing and Equipment Cleaning | Yes | Unknown | No |
| Truck Cleaning | N/A | N/A | N/A |

* Shaded cell indicates that JSC has already implemented or has begun to implement the alternative

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# 1 0

# INTRODUCTION

# 1 0 INTRODUCTION

This report presents the findings of a Feasibility Study (FS) conducted to evaluate feasibility of the Pollution Prevention/Waste Minimization (PP/WM) and water conservation opportunities identified during the 1994 PP/WM Audit of the Jordan Sulpho-Chemicals Company (JSC) facility The report provides a summary of the findings of the PP/WM audit, an evaluation of the technical and engineering feasibility of the potential PP/WM options, an evaluation of the costs to implement each of the options, and selects the recommended alternative(s) based on the cost/benefit analysis

## 1 1 BACKGROUND

Under Contract No 278-0288-00-4026-00 with the United States Agency for International Development (USAID), Development Alternatives, Inc (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber)

The IWDP is being performed in three phases The first phase required completion of ten PP/WM audits by DAI and its sub-contractors The second phase requires completion of Feasibility Studies for four of the audited facilities Finally, demonstration projects will be completed for two selected FS facilities

Harza Consulting Engineers and Scientists (Harza), Chicago, Illinois, USA, and Science Applications International Corporation (SAIC), McLean, Virginia, USA, have been retained as the subcontractors to lead the audits and feasibility studies The Royal Scientific Society (RSS) of Jordan, was selected as the local consultant to assist the lead consultants in the conduct of the audits and studies, and in report development The PP/WM audit and the feasibility study for the JSC facility was conducted by the SAIC/RSS team

## 1 2 OBJECTIVES

The facility PP/WM audits were designed to assess the potential techniques for PP/WM and water conservation at the study facilities The audits evaluated and identified possible PP/WM, wastewater clean-up, and water conservation techniques that were appropriate for the study facility

In particular, the audit procedures included the following activities

1 Review general industry background data and identify "state-of-the-art" wastewater management and processing practices

2 Work on-site with industry representatives, MWI and the Chamber officials, and other interested parties, to review current processing procedures and identify possible options for PP/WM and water conservation



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3 Prepare a report that evaluates possible PP/WM and water conservation alternatives and provides recommendations to the industry

In order to complete the first objective, a comprehensive literature review was performed This review included searches of the U S EPA Pollution Prevention Information Clearinghouse (PPIC) repository (and its corresponding database PIES), on-line library catalog databases, pollution PP/WM bibliographical references, and personal contacts with pollution prevention specialists The review resulted in the identification of numerous references with a range of very general to very specific PP/WM techniques Source documents were assessed to determine their applicability to this project and categorized appropriately The findings of the background document were included in Appendix F of the PP/WM audit report

Following completion of the literature review, the audit team performed the on-site audit of the JSC facility The audit was performed with close consultation of industry representatives to ensure that they were aware of and supported proposed actions Audit activities included the careful gathering of baseline water use and waste generation data, identification and assessment of potential PP/WM and water conservation options, and solicitation of ideas and proposals from management and production line staff The audit findings, conclusions, and recommendations were documented in the December 1994 report titled "Sulfur Chemicals Industry Audit Report, Jordan Sulpho-Chemicals Company, Jordan (USAID 1994)

Based on the findings of the PP/WM audit reports prepared for the various industrial sectors, four facilities were selected for the feasibility study phase of the project The purpose of the feasibility studies is to provide a technical (engineering) and cost evaluation of the PP/WM and water conservation alternatives provided in the audit reports, and to provide recommendations regarding the most appropriate and cost effective control techniques

## 1 3 REPORT CONTENTS

This report provides the findings of the FS prepared by the FS Team during June and July 1995 The FS report provides recommendations for the development of a site-specific program that meets the specific needs and goals of the JSC facility Selected alternatives include both PP/WM and water conservation techniques (e g , housekeeping practices, alternate waste disposal practices, etc ) and suggestions for PP/WM training for facility staff and follow-up studies to assess program successes

The report is organized into 6 sections that provide, a summary of the PP/WM audit of the JSC facility (Section 2 0), a description of the FS procedures and documentation (Section 3 0), a technical evaluation of the feasibility of the PP/WM opportunities identified during the audit (Section 4 0), an evaluation of the costs to implement each of the PP/WM opportunities identified during the audit (Section 5 0), and the conclusions and recommendations of the FS based on the cost/benefit information developed in Sections 4.0 and 5 0 (Section 6 0)

Several appendices are also included in the report to provide supporting documentation and reference materials The appendices include "Preliminary Engineering Plans for the STS Facility" (Appendix A) and "Proposed Location of Monitoring Wells" (Appendix B)

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# SUMMARY OF AUDIT FINDINGS

## 2.0 SUMMARY OF AUDIT FINDINGS

The "Sulfur Chemicals Industry Audit Report, Jordan Sulpho-Chemicals Company, Jordan (USAID 1994) presented the findings of the audit conducted at the Jordan Sulpho-Chemicals Company (JSC) facility on September 20, 1994, and the results of the subsequent discharge monitoring conducted by the audit team on September 25, 1994 The report provided recommendations for the development of a site-specific program to meet the specific needs and goals of the JSC facility Audit recommendations included both PP/WM techniques (e g , water conservation techniques, housekeeping practices, alternate waste disposal practices, etc ) and suggestions for PP/WM training for facility staff and follow-up studies to assess program successes

### 2 1 PROCESS OVERVIEW

The JSC facility produces a variety of chemical products used to manufacture soaps, detergents and cleaning products Most of the chemicals produced are sulfur-based, however, the facility also produces sodium silicate and fatty acid amides which do not contain sulfur The major production plants in the JSC facility include the following

- Sulfonation/Sulfation Plant
- Saponification Plant
- Sodium Silicate Melting and Dissolution Plant
- Sodium Toluene Sulfonate (STS) Plant
- Alkanolamides Plant

### 2 2 AUDIT FINDINGS

**Water Use and Balance**

The JSC facility's total water requirement was dependent on whether water was supplied by tanker or drawn from JSC's private well Where water was received from tankers, the facility required approximately 90 cubic meters ($m^3$) per day of fresh water for all uses except potable water When the reverse osmosis (RO) unit was in operation, the facility water use increased to approximately 110 $m^3$/day due to the RO reject and membrane washing streams

The specific water uses for each of the major plant areas of the JSC operation are described below

Sulfonation/Sulfation

Excluding the central cooling and steam systems, the total water used in the sulfonation plant was approximately 9 7 $m^3$/day, or 11 percent of the total facility water consumption Water was used in the sulfonation/sulfation plant for the following purposes

- Raw Material Dissolution
- Scrubber Water
- Product Stabilization
- Contact Cooling
- Cleaning

In addition to these process specific uses, the sulfonation plant also used non-contact cooling water and steam from the facility-wide recirculated cooling system, and the steam was from the central boiler system

Saponification

Excluding the central cooling and steam systems, the saponification plant used approximately 6 5 $m^3$/day of fresh water, or about 7 percent of the total facility consumption Water was used in the saponification plant for the following purposes

- Raw Material Dissolution
- Process
- Cooling and Steam
- Cleaning

In addition to these process specific uses, the saponification plant also used non-contact cooling water and steam from the facility-wide recirculated cooling system, and the steam was from the central boiler system

Sodium Silicate Production

The total water consumption for the sodium silicate plant (melting and dissolution) was estimated to be 20 8 $m^3$/day, or 23 percent of the total facility water consumption Water was used in the sodium silicate plant for the following purposes

- Dust Control
- Contact Cooling
- Product Dissolution
- Filter Washing
- Cleaning

Sodium Toluene Sulfonate Production

Water consumption in the STS plant was estimated to be 1 7 $m^3$/day, or about 2 percent of the total facility consumption Water was used in the STS plant for the following purposes

- Raw Material Dissolution
- Process
- Cleaning

In addition to these process specific uses, the STS plant used non-contact cooling water and steam from the facility-wide recirculated cooling system, and the steam was from the central boiler system

Alkanolamides Production

In general, the processes used for manufacturing alkanolamides did not use water

Cooling, Steam, and Other Water Uses

The JSC facility utilized a recirculated cooling system for process temperature control, and other various uses, for all plant operations except sodium silicate melting and dissolution Make-up water

was added as needed for losses due to blowdown, evaporation, and leakage, and was estimated at 6 $m^3$/day

The JSC facility also used a central boiler system to generate all of the steam used for process throughout the operation The JSC facility staff indicated that approximately 36 $m^3$/day of make-up water, or about 40 percent of the total water consumption at the JSC facility, was needed to maintain the steam system

The JSC facility reported that water was also used for cleaning tanker trucks, domestic uses, and for limited irrigation for landscaping These uses were considered minimal and did not significantly affect water consumption

**Wastewater Discharges**

All routine discharges of process wastewater from the JSC facility were collected and directed to the central wastewater collection basin Discharges to the basin included all process wastestreams, cooling water system blowdown, boiler blowdown, cleaning and maintenance discharges, and leaks and spills within the plant processing areas The waste collection basin reportedly has no effluent discharge to the wadi or groundwater, however, its proper operation and maintenance are imperative for protecting local surface and groundwater resources

While all wastestreams flow to the collection basin during normal operations, the facility reported that in wet weather, all process and storm water flows are directed directly to the wadi Based on general drainage characteristics of the facility, many of the areas where solid and liquid wastes are stored would also drain directly to the wadi

**Process Wastestreams**

Sulfonation

The following wastestreams were identified by the audit team

- Cooling Water and Condensate
- Contact Cooling Water
- Cyclone Discharge
- ESP Discharge
- Scrubber Discharge
- Dryer Condensate
- Cleaning Water

Saponification

The audit team determined that during normal operation there was no discharge of wastewater from the saponification process A wastestream, however, was generated during cleaning and maintenance activities

Sodium Silicate Production

The processes involved in the production and dissolution of sodium silicate resulted in the generation of several wastestreams The following discharges were identified



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- Contact Cooling Water
- Storage Tank Sediment
- Filtered Solids
- Cleaning Water

Sodium Toluene Sulfonate Production

The STS manufacturing plant generated wastewater during the reaction process as well as from product drying and area maintenance The following wastestreams were identified

- Process Wastestream
- Dryer Condensate
- Cleaning Water
- Contaminated Cooling Water

Alkanolamides Production

The production of alkanolamides from fatty acids generated a wastestream during the reaction process Vapor from the reactor was condensed, cooled, and separated into two phases, aqueous, and "pasty waste "

When alkanolamides were produced from methyl esters, the vapors generated by the process contained methanol The methanol produced by the reaction was collected by JSC and sold as a useful by-product

Cooling Water, Boilers and Other Waste Generating Activities

The JSC facility maintained a water treatment system, a centralized cooling water system, a centralized steam generation unit, and had several other miscellaneous water uses Several of these activities generated significant wastewater discharges These wastestreams included

- Groundwater Well Sediment
- RO Reject
- Softener Regenerate
- Boiler Blowdown
- Oil Spill Clean-up
- Cooling System Blowdown
- Tanker Washing
- Domestic Wastewater

**Materials Handling and Storage**

During the site visit to the JSC facility, the audit team noted several areas within the JSC facility where protection against spills and accidental discharges had been provided These included containment structures around storage tanks, covered areas for raw materials storage, and concrete pads and berms designed to prevent spills to the soil In addition, the JSC technical manager indicated that a new materials storage hanger had recently been constructed, and that three larger hangers would soon be built These buildings will reportedly be used to house raw materials, intermediates, products, and wastes, and will help to prevent contamination of soils and storm water runoff

While certain PP/WM measures were in place at the JSC facility, the audit team noted several areas where storage, handling, loading, unloading, or waste disposal practices provided opportunities for spills, leaks, and contamination of soil and groundwater Materials observed in these areas included raw materials, intermediates, final products and solid and liquid wastes



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**Waste Collection Basin**

The centralized waste collection basin provided no treatment to the wastes collected The JSC technical manager reported that there had been no discharge from the basin during its 4 years of operation In addition, the manager also reported that neither liquid nor solid waste has been removed from the basin by waste hauler The technical manager indicated that evaporation accounted for significant losses from the basin, however, an actual flow balance had not been performed around the collection basin to determine the fate of the various wastestreams Without such a flow balance, it was unclear whether any of the wastewater in the basin had seeped into the surrounding soils

Results of the analyses performed following the audit indicated that the basin contains high concentrations of oxygen demanding organic pollutants, suspended and dissolved solids, nitrogen, surfactants, and some toluene These pollutants and concentrations were consistent with the types of wastes known to be discharged to the basin The oxygen demanding pollutants also appeared to be generally biodegradable due to the relatively low COD/BOD ratio (approximately 2)

While toluene was determined to be present in the basin, its concentration at the time of sampling was not particularly high However, its presence indicated that some amount of toluene was entering the wastestream and collecting in the basin It is also possible that other toxic organic pollutants may be present due to the breakdown of toluene or other organic material in the basin

**Air Emissions and Solid Wastes**

While the focus of the PP/WM and water conservation audit was related to water use and wastewater generation, the solid wastes generated, and the pollutants discharged to the atmosphere were also examined.

Air Emissions

The principal atmospheric discharge generated at the JSC facility, was the $SO_2$ wastestream from the sulfonation plant In addition to the $SO_2$ emission, the burners for facility's boiler operation, sodium silicate kiln, and multi-purpose dryer, also generated an air emission The JSC facility also reported that it had burned waste sulfur to reduce its quantity of solid waste This open burning of sulfur resulted in emissions of $SO_2$

Silica and sodium carbonate dust was generated during the measuring and blending process, and sodium silicate dust was generated following the melting process from handling and storage of rock sodium silicate Dust control was provided by a water spray in mixing of raw materials, and workers were reportedly provided with filters

Although the STS plant was not in operation during the audit, it was reported that toluene fumes were occasionally present in this area

## Solid and Drummed Wastes

The JSC facility operations resulted in the generation of significant quantities of solid and drummed waste The JSC staff indicated that approximately 645 drums had accumulated at the facility at the time of the audit In addition, the facility reported that an additional 10 tons of solid sulfur waste, and 10 tons of solid sodium sulfate waste were also stored on site

# 3 0

# FEASIBILITY STUDY PROCESS

## 3 0 FEASIBILITY STUDY PROCESS

The feasibility study was conducted in three phases corresponding to Sections 4 0, 5 0, and 6 0 of this report The first phase included a technical evaluation of the engineering feasibility of each of the PP/WM and water conservation opportunities identified during the audit The second phase analyzed the cost to develop and implement each of the opportunities and evaluated the benefit(s) of implementing the alternatives The third phase compared the findings of the technical evaluation and the cost/benefit analysis and provided recommendations as to which of the proposed PP/WM and water conservation alternative(s) were most appropriate for the JSC facility

### 3 1 TECHNICAL FEASIBILITY EVALUATION

The technical feasibility of each of the PP/WM and water conservation opportunities was evaluated to determine whether the proposed alternative was possible based on available technology and considering site-specific constraints at the JSC facility Where necessary, feasibility was further evaluated through the development of preliminary engineering plans and specifications The plans and specifications were outlined by the lead technical contractor (SAIC) and prepared in Jordan by the Royal Scientific Society (RSS) counterpart The results of the technical feasibility evaluation are summarized in Section 4 0, and supporting documentation (e g , engineering plans and specifications) is provided in the appendices of this report

### 3 2 PROJECT COST/BENEFIT EVALUATION

Following the development of technical plans and specifications for each of the PP/WM and water conservation opportunities, general cost estimates were developed, where necessary, by the in-country contractor (RSS) The costs included only capital costs necessary to implement and operate each of the proposed activities The results of the cost evaluation were then compared to the environmental benefit(s) that were established during the PP/WM audit The comparison of the costs and benefits is provided in Section 5 0 Additional supporting documentation is also provided in the appendices of this report

### 3 3 DETERMINATION OF SELECTED ALTERNATIVE(S)

Having completed the technical feasibility and cost/benefit evaluations, the FS team summarized findings of the evaluations for each of the potential alternatives and selected the most appropriate techniques

# 4.0

# TECHNICAL FEASIBILITY EVALUATION

# 4 0 TECHNICAL FEASIBILITY EVALUATION

During the audit of the JSC facility, conducted on September 20, 1994, and during several subsequent visits, the audit team identified a variety of PP/WM opportunities While the focus of the audit was on PP/WM activities related to wastewater discharges, several opportunities related to air emissions, and solid wastes were also identified The audit team evaluated the JSC facility operation and identified potential opportunities to reduce loadings from the facility to the collection basin and, under storm conditions, to the wadi In addition, several PP/WM techniques described in this report could result in the recovery of useful materials by the JSC facility The technical feasibility of each of the opportunities is provided in Section 4 1, below

In addition to PP/WM opportunities, water conservation is also an extremely important concern in the Zarqa Basin and throughout Jordan In order to optimize water use, business and industry should carefully monitor flows and uses within facility operations and develop a written strategy to coordinate water conservation activities While water conservation is an important concern, the use of water at the JSC facility is necessary for the production of a high quality product The water conservation opportunities were, therefore, evaluated to assess possible adverse impacts on production processes JSC The results of the feasibility evaluation for the water conservation opportunities are provided in Section 4 2, below

## 4 1 POLLUTION PREVENTION/WASTE MINIMIZATION TECHNIQUES

In general, the PP/WM opportunities identified for the JSC facility could be arranged in three general categories

- Process Control,
- Materials Handling and Storage, and
- Control of Other Waste Generating Activities

The PP/WM opportunities identified for each of the categories are provided in the following sections Following the presentation of each alternative, a summary of the technical feasibility of developing and implementing the alternative is provided Where engineering analyses were required to conduct the feasibility analysis, the supporting documentation is referenced in the appendices of this report

### 4 1 1 Feasibility of Process Control Opportunities

During the audit, the audit team identified a number of PP/WM opportunities directly related to the operation of the unit processes at the JSC facility PP/WM opportunities in this category included, optimization of raw material use, modifications to equipment maintenance practices, optimization of process operations (including reactors), and modification of routine cleaning and maintenance operations While the PP/WM opportunities identified in this section are intended to reduce waste generated, the audit team is aware that changes to process operations may result in unanticipated consequences The options presented, therefore, were reviewed by JSC facility staff to ensure that manufacturing processes would not be adversely affected



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Sulfonation/Sulfation

Several PP/WM opportunities were identified for the sulfonation plant at the JSC facility These included

- Reduction in Use of Branched Alkylbenzene - The JSC facility should evaluate the opportunity for reducing or eliminating the use of branched alkylbenzene Branched alkylbenzene products are not as susceptible to biodegradation as their linear counterparts Minimization of the use of this raw material, therefore, would enhance the treatability of the wastes generated in the sulfonation plant

  **Technical Feasibility Evaluation** This alternative relies exclusively on the manufacturing decisions of the JSC management The decrease or elimination of the use of branched alkylbenzene will not require any changes in equipment or technology

  According to information provided in the July 5, 1995 letter from JSC, the use of branched alkylbenzene has never exceeded 15 percent total capacity During the current year, JSC has rejected all inquiries for this type of sulphonic, and they do not anticipate further use of this material

- Sulfonator Optimization - The JSC facility should evaluate and optimize the operation of the sulfonation film reactor to eliminate the generation of unreacted or charred materials Film thickness in the reactor could be maintained at the optimum thickness by precise control of raw material feed rate Temperature must also be carefully controlled to reduce the generation of charred material that is separated in the cyclone Reactor optimization will also reduce $SO_3$ waste that is removed by the ESP

  **Technical Feasibility Evaluation** In its letter of July 5, 1995, the JSC facility reported that the sulfonator utilizes the most modern design and is already operated under optimized conditions Additional optimization is not technically feasible

- Utilization of Sealless Pump - The JSC facility should investigate the possibility of using a sealless pump for transporting molten sulfur This would prevent contamination of cooling water

  **Technical Feasibility Evaluation** This alternative would require the removal and disposal of the existing pump and the purchase and installation of a new sealless pump The sealless pump technology is readily available and no new piping would be required Due to the relatively minor installation requirements no construction plans are required

  In its letter of July 5, 1995, the JSC facility indicated that a new sulfur pump had been ordered and would soon be in place In addition, the cooling water used for the pumps is disconnected from the main cooling system

- Leak Control - The JSC facility should provide additional maintenance to minimize leaks within this plant

**Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to identify and correct leaks, however, no new equipment or technology would be required

In its letter of July 5, 1995, the JSC facility reported that it had undertaken additional steps to reduce leaks, including use of a new internal system for daily maintenance

- Spill Prevention - The JSC facility should develop measures and provide training to staff in order to reduce the potential for spills within the plant

  **Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to identify the potential sources of spills, to develop procedures and practices to reduce the occurrence of spills, and to train staff in these practices, however, no new equipment or technology would be required Guidance for developing spill prevention plans is readily available

  In its letter of July 5, 1995, the JSC facility reported that it had undertaken additional steps to reduce spills, including use of a new internal system for daily maintenance

- Sulfur Quality Control - The JSC facility should investigate the cost/benefit of obtaining a cleaner sulfur supply to reduce the volume of solid sulfur waste generated by the sulfur filters In addition, more careful raw material handling in the sulfur storage area could result in introduction of fewer impurities from cleanup of spillage

  **Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to identify all available suppliers of sulfur, and to evaluate the cost and benefit of utilizing a higher grade of the raw material In addition, staff time would be required to evaluate the raw material storage and handling procedures to minimize contamination It is possible that this evaluation will determine that additional storage area, and/or raw sulfur handling equipment may be needed to reduce contamination, however, neither plans nor specifications can be developed until the evaluation is performed

  In its letter of July 5, 1995, the JSC facility indicated that it currently purchases sulfur, that meets its manufacturing specifications, from neighboring arab countries at reasonable prices While JSC plans to continue using current suppliers, it has begun investigating the possibility of modifying the melting unit to eliminate, or minimize, the generation of solid sulfur waste

- Catalytic Converter Optimization - The JSC facility should evaluate the operation of the catalytic converter to optimize operation and reduce $SO_2$ emissions Temperature control within the converter could be carefully monitored and optimized in order to maximize $SO_3$ generation and minimize the residual $SO_2$

  **Technical Feasibility Evaluation** The optimization of this process will require JSC staff to carefully monitor and document the performance of the catalytic converter under various operating conditions Logs should be developed to accurately track operating parameters versus $SO_2$ generation to identify optimum performance Based on the results of this analysis, the unit would then be closely monitored to ensure that optimum conditions are maintained

The implementation of this alternative would require some additional staff time to track performance and to evaluate the results, however, no new equipment or technology would be required

Saponification

PP/WM opportunities identified for the saponification plant included

- Reactor Optimization - The saponification reaction temperature should be optimized to avoid line blockages and unnecessary product wasting during cleaning (unblocking) operations

  **Technical Feasibility Evaluation** In its letter of July 5, 1995, the JSC facility indicated that it considered the unit to be fully optimized The reactor is operated using advanced measuring and control equipment that minimizes waste generation and optimizes product production

- Leak Control - The equipment in the saponification plant should be maintained more rigorously to reduce steam leaks Audit findings indicated that steam leaks were causing soap contamination of steam condensate, resulting in its discharge to the basin instead of recycling to the condensate recovery system

  **Technical Feasibility Evaluation**· The implementation of this alternative would require some additional staff time to identify and correct leaks, however, no new equipment or technology would be required

- Production Schedule Optimization - The production schedule should be modified and optimized to prevent frequent changes of products and reduce start-up losses Practices observed during the audit resulted in the generation of significant quantities of off-spec soap during start-up operations While the JSC facility stored the material for reprocessing, its storage capacity was limited, and it appeared that some quantity of soap would be wasted

  **Technical Feasibility Evaluation** In its letter of July 5, 1995, JSC reported that it had designed a recovery system to eliminate waste generation during product changeover JSC indicated that it is unable to modify its production schedule due to customer and market requirements

Sodium Silicate Production

PP/WM opportunities identified for the sodium silicate melting and dissolution operations included the following

- Elimination or Minimization of Contact Cooling - The JSC facility should investigate the opportunity for using a non-contact cooling water stream, or measures to minimize use of contact cooling water, for the casting belt Use of a non-contact system would eliminate the periodic wasting of the contaminated cooling water wastestream (7 33 $m^3$/day) to the collection basin Alternatively, JSC could minimize the contamination of the contact cooling water and more effectively use the stream for product dissolution The current wastestream was reported to contain 5 -10 percent sodium silicate

**Technical Feasibility Evaluation** The implementation of this alternative would require significant alteration of the plumbing for the current contact cooling system In addition, the effectiveness of the non-contact cooling (or limited) contact cooling system may require modifications to the casting belt operation (e g , extending cooling time) In order to evaluate the technical feasibility of using alternative cooling procedures, it was necessary to develop preliminary engineering plans and specifications The preliminary engineering evaluation identified the following constraints

- The casting belt cannot be elongated, and there is insufficient space for a new belt
- Cooling time cannot be increased by reducing the belt speed since the belt operation is constrained by the operation of the rotary kiln
- Cooling is currently achieved mainly from evaporation of water coming in contact with the hot belt plates
  Silicate cooled from 1000°C to 200°C
  Cooling water in at 25°C, out at 60°C
- JSC has added an air blower near the end of belt, but it has not significantly affected the cooling efficiency
- JSC and audit team could not identify alternative non-contact cooling technology applicable to this manufacturing process

Based on these technical limitations, the most reasonable alternative is to reposition the cooling water jet spray piping at an angle to the casting belt in order to maximize cooling water contact with the belt plates, and minimize contact with the sodium silicate This can be accomplished by JSC staff with minimal cost and effort

- Sediment/Filter Solids Control - The JSC facility should investigate possible ways to minimize sediment in the dissolved sodium silicate storage tanks Less sediment in these tanks would result in less waste from the tank and filter to be removed, and flushed to the waste collection basin, and higher quality product With respect to product quality, residual solids in the dissolved sodium silicate can damage pumps in powder detergent plants, thus, reducing the attractiveness of the JSC product Methods to reduce sediment generation should include

  - Increasing the purity of raw materials, and in particular, the silica sand Impurities in the silica sand result in unreacted material in the rock sodium silicate that will not be dissolved in the dissolution process
  - Optimizing the operation of the kiln to maximize reaction of raw materials and reduce unreacted by-products sent to the dissolution unit
  - Optimizing the dissolving conditions in the autoclave to ensure that dissolution occurs to the highest extent possible

  **Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to identify all available suppliers of silica, and to evaluate the cost and benefit of utilizing a higher grade of the raw material Additionally, the optimization of this process will require JSC staff to carefully monitor and document the performance of the dissolution process under various operating conditions Logs should be developed to accurately track raw material feed rates, and other operating parameters versus solids generation Based on the results of this analysis, the reactor would then be closely monitored to ensure that optimum conditions are maintained

The implementation of this alternative would require some additional staff time to track performance and to evaluate the results, however, no new equipment or technology would be required

In its letter of July 5, 1995, the JSC facility indicated that the filter solid waste generation is related directly to the quality of the silica sand used in the process, and to the handling of the finished products JSC reports that it is negotiating with its local supplier to develop a new quality of sand that contains less heavy oxides Parameters were also modified to obtain a higher purity product and minimize unreacted materials that remain as filter cake With respect to product handling, the facility is utilizing a new overhead crane to minimize solid waste generation

- Dust Control - The JSC facility should implement additional dust control measures to reduce opportunities for worker exposure to silica dust Exposure to silica dust can result in silicosis, a significant long-term respiratory disorder

  **Technical Feasibility Evaluation**· The implementation of this alternative would require some additional staff time to identify the sources of silica dust, to develop procedures and practices to reduce dust generation, and to train staff in these practices It is also possible that new equipment or technology, such as dust suppression devices, may be required, however, neither plans nor specifications can be developed until the evaluation is performed

  In its letter of July 5, 1995, the JSC facility reported that it has ordered a reliable system to minimize worker exposure to silica dust

Sodium Toluene Sulfonate Production

In its letter of July 5, 1995, the JSC facility indicated that the STS plant has not been operated on a continuous basis since the time of the audit It is currently operated only for specific product requests According to JSC staff, a complete survey was performed two years ago to modify the production line in accordance with the latest technologies Dependent on budgetary constraints, JSC hopes to implement the plant modifications within the next two years

Independent of the survey that was developed by JSC, the audit team identified the PP/WM opportunities for the STS operation

- Elimination of Toluene Discharge - Water remaining following separation of toluene from the toluene/water mixture, should be stored and fully reused in the process in lieu of discharge to the collection basin Storage and reuse efforts may require construction of an additional storage tank in the STS facility Alternatively, the water contaminated with toluene could be treated by activated carbon, air stripping, or other means, and reused, or in some way segregated from other plant discharges Audit findings indicated that the waste collection basin contained detectable concentrations of toluene (0 45 mg/l) Based on JSC plant operations, the STS unit is the only source of toluene to the basin Confining all wastes generated by the STS operation, and segregating STS wastestreams from other plant discharges, would prevent toluene contamination from affecting overall plant wastewater characteristics

Technical Feasibility Evaluation The implementation of this alternative would require alteration of the plumbing and water collection systems in the STS operation In addition, the impact of the using the recycled water for this process will require close monitoring to ensure that the process is not adversely effected

In order to evaluate the technical feasibility of using alternative cooling procedures, it was necessary to develop preliminary engineering plans and specifications Based on the preliminary plans, the following constraints were identified

- Wash water from the intermediate tanks in the production area contains sodium sulfate and residual STS Floor contamination from this source is evident
- Concrete floor in production area is corroded causing difficulties in collecting waste material

Pollutant minimization in the area is technically feasible and can be accomplished by the following actions

- Repair concrete slab and install anti-acid chemical flooring (e g , ceramic tile) to concrete surface over an area of approximately 170 $m^2$ Install regular flooring tiles to 115 $m^2$
- Construct a pit to collect floor wash water and spills Install a stainless steel tank (0 5 $m^3$) in the pit
- Equip collection tank with a submersible sump pump (220V, 50Hz) and level control
- Direct intermediate tank wash water to a drying tank for material recovery by evaporation An unused stainless steel tank (12 $m^3$) is available on site for this purpose Install approximately 50 m of 1½ inch diameter stainless steel piping
- Direct floor wash water from the collection pit to the 12 $m^3$ tank
- Direct the separator and dryer lines into a stainless steel receiving tank of about 0 5 $m^3$ Install a pump (220V, 50 Hz) and approximately 10 m of 3/4 inch stainless steel piping
- Install activated carbon filter to treat effluent from the toluene/water separator (0 7 $m^3$/day) and dryer condensate (0 83 $m^3$/day) (Note the existing line from the dryer to the waste basin will need to be closed)
- Direct the stored water from the receiver tank to the activated carbon filter using a centrifugal pump (220V, 50 Hz) with a level control
- Install a 2 $m^3$ storage tank for treated water storage
- Construct a 3m x 1m x 0 8 m concrete slab for support of the intermediate tank, the activated carbon filter, and the treated water storage tank

[**Note** The annual operating costs for the unit will depend on the expense for replacement of the activated carbon in the carbon filters The need for replacement of the activated carbon will increase as the total organics concentration in the wastestream treated by the carbon column increases See Appendix A for diagrams and additional information]

- STS Cooling Water Segregation - The use of the central cooling water system for the STS plant should be eliminated by constructing an STS specific cooling system Additionally, a toluene leak detection system could be installed to minimize the loss of toluene to the cooling circuit Use of a system specifically for the STS plant would prevent contamination of the entire central cooling system (50 $m^3$)

**Technical Feasibility Evaluation** The implementation of this alternative would require significant alteration of the plumbing in order to remove the STS plant from the central cooling system and construct a new STS-specific cooling system In order to evaluate the technical feasibility of using alternative cooling procedures, it was necessary to develop preliminary engineering plans and specifications

The engineering analysis performed by the FS team determined that it was unlikely that significant contamination of the cooling system could occur during the manufacturing process The JSC engineers indicated that no accidents relating to non-contact cooling water contamination had occurred during the nine years of operation of this unit Other sources of toluene contamination of the waste collection basin could be the dryer line and/or spills on the floor that are washed to the drain Floor repair, and modifications to cleaning practices described above, should minimize these releases Based on this analysis, the segregation of the STS non-contact cooling system was determined to be unnecessary at this time

- Leak Control - The equipment in the STS plant should be maintained more rigorously to reduce or eliminate possibilities for the cooling water and steam to become contaminated by toluene due to leaks Audit findings indicated that JSC must periodically blowdown the central cooling system, due in part to leaks of toluene to the system This results in a discharge of 50 $m^3$ of toluene contaminated wastewater to the collection basin, and requires refilling of the cooling circuit with fresh water

  **Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to identify and correct leaks, however, no new equipment or technology would be required

Alkanolamides Production

The operations at the Alkanolamides facility did not result in the generation of significant amounts of waste, however one PP/WM opportunity was identified by the audit team This opportunity related to the discharge of "pasty" wastes to the collection basin To reduce the discharge of this wastestream to the collection basin, the JSC facility should ensure that all of the pasty wastes generated are drummed Audit findings revealed that some of the pasty waste is currently discharged to the basin, however, the quantity was reported to be quite small

**Technical Feasibility Evaluation** The implementation of this alternative would require some additional staff time to collect and drum the pasty waste, however, no new equipment or technology would be required

In its letter of July 5, 1995, the JSC facility indicated that the pasty waste would be drummed and stored in a specially designated area

4 1 2 Materials Handling and Storage

During the audit site visit, the audit team noted a variety of materials handling and storage practices at the JSC facility that could result in the discharge of pollutants to the wadi during a storm event, or which could contaminate surrounding soils



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In its letter of July 5, 1995, the JSC facility indicated that it had designed additional storage facilities and that it hoped to begin construction of these storage facilities in the near future In the interim period, JSC indicated that it has begun applying a comprehensive maintenance program in order to minimize impacts In particular, the facility reports that it now limits tanker trucks to one type of product in order to minimize rinsing, and it now uses new barrels in order to eliminate barrel cleaning

Independent of the practices now being undertaken by JSC, the audit team identified the following recommendations regarding materials handling and storage

1 Concrete loading and unloading areas should be constructed utilizing containment berms and rain covers to isolate spills, prevent soil contamination, and eliminate storm water runoff

<u>Technical Feasibility Evaluation</u> The audit identified four specific areas of the JSC facility where loading and unloading activities resulted in spills including 1) the oil unloading area, 2) the loading area for raw materials and products near the sulfonation plant, 3) the fatty acids unloading area above the STS plant, and, 4) the fatty acids unloading area between the toluene storage tanks and the STS plant To implement this alternative, the JSC facility should eliminate one of the two fatty acid unloading areas, preferably, the one above the STS plant, in order to minimize construction costs For the three remaining loading and unloading areas, concrete pads would be constructed with berms and drains to collect spilled materials Covers (e g , corrugated fiberglass or sheet metal) will be provided for the pads to prevent storm water from washing spilled materials to the wadi; however, the covers will be designed to ensure that equipment can move freely in and out of the loading and unloading areas and that these activities are not impeded

In order to more fully evaluate these alternatives, preliminary engineering plans were developed The preliminary plans for each of the loading and unloading facilities are as follow

<u>Fuel Oil Unloading Area</u>

- Install a concrete slab measuring 10 m x 4 m, including a drainage trench and collection pit
- Install a 10 m x 4 m corrugated steel cover at a height of 4 m
- Improve handling procedures during loading and unloading to reduce fuel spillage
- Enclose the sides of the concrete pit directly below the unloading area to capture leaks and spills Enclosure will require construction of two walls 80 cm high at a total length of 7 m
- Install an oil/water separator
- Extend the trench line to the pit area (a length of 16 5 m) and add a manhole
- Combine the flows from the pit and the recovered oil from the boiler maintenance facility at the manhole, and direct flows to the oil water separator Effluent from the oil/water separator will be discharged to the waste collection basin

<u>Loading Area for Raw Materials and Products Near the Sulfonation Plant</u>

- Based on an engineering evaluation, it was determined that installation of a cover in this area would not be appropriate due to the potential collection of $SO_3$ fumes from the sulfonation plant Therefore, the only need is a concrete pad measuring 12 m x 11 m

Fatty Acid Unloading Areas above the STS Plant and between the Toluene Storage Tanks and the STS Plant.

- Based on an engineering evaluation, the following additional information was obtained regarding the unloading activities

  - Combining the two unloading facilities is not practical due to the differing types of unloading operations Therefore, containment will be required for both areas
  - The drummed material (solid fatty acids) is melted using live steam directed into an externally insulated container Approximately 200 kg of steam is used per 8 drums, each containing 200 kg of raw material
  - The drums are initially unloaded into an open receiver tank where some of the contents oxidize upon contact with air This oxidation contaminates the soap product
  - The melting tank is rusty and contains holes that allow steam leakages
  - Tankers are unloaded using a piping system from an area above the STS plant into the same open melting tank used for the drums
  - The raw material in the tanker outlet is usually solidified This material is melted by directing live steam into the outlet while the valve is open This is a major source of spillage
  - Covers in this area may result in the collection of toluene fumes, thus, they are not appropriate

  The following design considerations, therefore, are recommended for the unloading areas

  Tanker Unloading Area (above the STS plant)

  - Install a concrete pad measuring 18 m x 6 m, including a rain water collection trench and a collection pit
  - Unload tankers directly to the material storage tanks rather than to the open receiving tank
  - Improve handling procedures during unloading to prevent spillage
  - Install an alarm system in the raw material storage tanks to prevent overflow
  - Install a material circulation system in the tanker trucks to prevent solidification of the raw material at the outlet valve

  Drum Unloading Area (between toluene storage tanks and the STS plant)

  - Install a jacket around the melting tank to allow indirect steam heating This procedure will conserve approximately 200 kg of steam condensate for each 8 drums of raw material
  - Use drum pump to pump molten raw materials directly to the receiving tank
  - Close the receiving tank and install a level control to prevent overflow

2 Drummed and bagged raw materials, intermediates, products and wastes should be stored in covered areas with concrete floors and spill containment berms Storage in this manner would isolate spills and prevent storm water contamination

Technical Feasibility Evaluation. The technical feasibility of any attempt to control these impacts is contingent on two activities First, where there is a need to store products and wastes on-site materials on-site, pads (with berms and drains) and covers should be constructed Second, wherever possible, empty drums, drummed wastes, bagged wastes, and other materials should be sent off-site for proper disposal Based on discussions with JSC staff, there is currently no solid waste disposal site available in Jordan that will accept the facility's wastes Without such a facility, JSC will be required to indefinitely store all of its solid wastes (as is currently done)

In order to design raw material and waste storage areas, an estimate of the total material to be stored was first be developed At the time of the audit, there were an estimated 650 drums of raw materials and wastes stored at the JSC site Based on discussions with JSC staff, it is estimated that storage will be required for 800-1000 drums Using this estimate, a storage area of approximately 360 $m^2$ will be required at the facility

The storage areas will require concrete pads with berms and drains to collect spilled materials Corrugated steel covers will be provided for the pads to prevent storm water from washing spilled materials to the wadi, however, the covers will be designed to ensure that equipment can move materials in and out of the storage areas in an unimpeded manner

3 The drainage hole cut in the wall of the sulfur melting room should be sealed This would prevent the discharge of pump cooling water and condensate from the heating jacket from reaching the bare ground near the sulfonation plant Additionally, the waste sulfur accumulating in the area of the melting unit should be periodically removed by dry methods to lessen the sulfur contamination of the water collecting in this area

Technical Feasibility Evaluation This alternative can be implemented with minimal effort, and does not require an engineering analysis Some additional staff time will be required to repair the small hole in the wall and to provide cleaning and maintenance in the sulfur melting room

4 Leaks and spills throughout the JSC facility should be removed by absorbent materials, or other dry cleaning methods, and not rinsed to the collection basin In addition, where barrels are used to collect overflow from process units, these collection vessels should be replaced more frequently to ensure they do not overflow to the collection basin

Technical Feasibility Evaluation This alternative can be implemented with minimal effort, and does not require an engineering analysis Some additional staff time will be required, however, to provide cleaning and maintenance and to remove and dispose of the collected waste

5 Containment structures constructed to prevent spills from reaching bare ground or the wadi should be repaired and maintained to ensure their proper operation Where drains are located in these containment structures, they should be closed under normal circumstances, and opened only to remove uncontaminated storm water or washwater

Technical Feasibility Evaluation· The implementation of this alternative would require some additional staff time to inspect containment structures, to develop procedures and practices to ensure that valves and drains are properly operated, and to train staff in these practices, however, no new equipment or technology would be required

6 Tanker truck and barrel washing should be performed off site at a suitable location, or within an area of the JSC facility designed to contain truck and barrel washing discharges

Technical Feasibility Evaluation This alternative can be implemented with minimal effort, and does not require an engineering analysis Based on comments from the JSC facility, these practices have already been modified

4 1 3 Control of Other Waste Generating Activities

The audit team identified several additional PP/WM actions that did not relate directly to process operations, or to the handling and storage of materials Instead, these opportunities addressed the disposition and treatment of the solid and drummed liquid wastes generated by various processes, the operation of central utilities, such as the cooling and steam systems, and operation of the waste collection basin Opportunities in these specific areas are provided in the following sections

4 1 3 1 *Solid and Drummed Wastes*

PP/WM opportunities related to the treatment and disposition of wastes generated by the JSC facility included the following

- Utilization of Sulfur Wastes - The JSC facility should promote the use by outside firms of the solid sulfur waste generated by the sulfonation process The audit findings indicated that the JSC facility generated approximately 12 tons/yr of solid sulfur waste Some of the waste material has been sold to farmers in the past, however, the majority is stored on site and/or burned in open areas An estimated 10 tons is currently stored on site

  Technical Feasibility Evaluation· The implementation of this alternative does not require an engineering analysis, however, staff time will be required to identify potential end users of the sulfur, and obtain clearance from military authorities that oversee use of sulfur Identification of potential users of this material would be greatly improved if a "waste exchange" program were to be developed and implemented by Jordanian environmental agencies

  In its letter of July 5, 1995, the JSC facility indicated that it was actively attempting to identify regular customers for its sulfur wastes JSC encouraged the PP/WM team's efforts to establish a waste exchange program

- Utilization of Charred Material - The JSC facility should investigate the re-introduction of additional charred material, generated in the sulfonation reactor and removed by the cyclone, to the final product While the charred material is off-color, it can be combined with the product in small quantities without affecting product quality This practice is currently conducted on a small scale, however, it should be maximized to decrease the wasting of excess charred material

  Technical Feasibility Evaluation The implementation of this alternative does not require an engineering analysis, however, staff time will be required to evaluate the use of the off-spec material In particular, staff would need to closely monitor and document the effects of the use of this material on the quality of the product in order to ensure that the product is not adversely effected The optimum feed rate would then be determined and utilized

- Utilization of Sodium Silicate Sediment - The JSC facility should investigate alternative uses for the sediment collected in the dissolved sodium silicate storage tanks and for the solids removed from the plate filters used to remove impurities during transfer from the storage tanks to the final product tank The audit findings indicated that some of these solids were used for building construction purposes As the material is solid, and relatively inert, it should be collected as a solid and used, where possible, or collected and disposed of as a solid waste

  Technical Feasibility Evaluation The implementation of this alternative does not require an engineering analysis, however, staff time will be required to identify potential end users of the sodium silicate sediment Identification of potential users of this material would be greatly improved if a "waste exchange" program were to be developed and implemented by Jordanian environmental agencies

  In its letter of July 5, 1995, the JSC facility indicated that it was actively attempting to identify regular customers for its sodium silicate wastes JSC encouraged the PP/WM team's efforts to establish a waste exchange program

- Utilization of Sodium Sulfate Wastes - The JSC facility should investigate the use by other companies of the waste sodium sulfate generated by the STS process Additionally, the process should be optimized to reduce the generation of this material to the extent possible Audit findings indicated that approximately 10 tons/yr of this solid waste was generated by JSC While the sodium sulfate is slightly contaminated by STS product, other firms may be able to use this material

  Technical Feasibility Evaluation The implementation of this alternative does not require an engineering analysis, however, staff time will be required to identify potential end users of the sodium sulfate wastes Identification of potential users of this material would be greatly improved if a "waste exchange" program were to be developed and implemented by Jordanian environmental agencies

  In its letter of July 5, 1995, the JSC facility indicated that it was actively attempting to identify regular customers for its sodium sulfate wastes JSC encouraged the PP/WM team's efforts to establish a waste exchange program

Each of the above suggestions relate to the use of "waste" materials generated by the JSC facility by other individuals or companies While these materials are considered wastes by JSC, they may be of use as raw materials for others Industries and trade organizations in the US and other nations have developed "waste exchange" programs to facilitate the identification of such opportunities A waste exchange program identifies wastes generated by industries and notifies other industries of the availability of these materials at little or no cost Governments may also play a role in the waste exchange program by acting as a clearinghouse for this type of information Utilization of these materials as useful products will reduce not only the cost of disposal for the generators, but provides a source of low cost raw materials for others

4 1 3 2 *Utilities Wastes*

PP/WM opportunities related to the operation of central utilities at the JSC facility included

- Utilization of RO Reject - RO reject and membrane filter water should be removed from use in irrigation of adjacent farm land The reject water should instead be evaporated, or disposed of in an environmentally sound manner, to prevent TDS contamination of soil Audit findings indicated that approximately 21 $m^3$/day of RO reject, which contained a TDS concentration exceeding 7,000 mg/l, was provided to a local farmer for irrigation Although the farmer reportedly mixed the RO reject with additional well water, it is likely that the irrigation water would exceed the 202 Standards

  **Technical Feasibility Evaluation:** The implementation of this alternative would be accomplished by establishing an evaporation pond or a "leach field" to properly dispose of the waste stream The use of either of these types of disposal units would require some construction, however, the primary technical concern would be the land area needed for the units It is unlikely, that either unit could be easily constructed and operated within current property boundaries

  In its letter of July 5, 1995, the JSC facility reported that it planned to identify a source of water more reliable than its existing well for plant uses If identified, this would eliminate the need for operation of the RO unit

- Utilization of Recovered Fuel Oil - The JSC facility should revise boiler maintenance procedures to prevent the discharge of waste fuel oil to the waste collection basin In addition, an oil water separator should be installed prior to the waste collection basin to prevent waste fuel oil from contaminating the basin The audit findings indicated that a thick film of waste oil was present on the surface of the waste collection basin and that oil was also present in the sediment sample withdrawn from the basin Recovered oil should be used for low quality burning purposes at the facility

  **Technical Feasibility Evaluation.** The implementation of this alternative would require the installation of an oil/water separator to treat the wastestream from the oil storage and boiler areas Installation of the separator would also require some plumbing modifications to segregate the wastestreams containing oil from the combined sewer system In order to evaluate this alternative more fully, a preliminary engineering plan was developed The evaluation indicated that the recovery of fuel oil was feasible and would utilize the oil/water separator described in Section 4 1 2 (Item 1) of this report

  In addition to the construction, staff time will be required to evaluate the use of the recovered oil for various fuel needs throughout the JSC facility In particular, staff would need to identify potential uses and experiment with the use of the recovered oil

  In its letter of July 5, 1995, the JSC facility indicated that it had identified other firms that were willing to accept all fuel recovered from the plant site



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- Leak and Spill Prevention - Leaks and spills throughout the JSC facility should be minimized to prevent contamination of the centralized cooling and steam systems Audit findings indicated that contamination of the cooling system by toluene and other materials, and of the condensate return system by various raw materials and products, resulted in periodic wasting of these systems to the collection basin

  Technical Feasibility Evaluation The implementation of this alternative would require some additional staff time to identify and correct leaks, however, no new equipment or technology would be required

- Domestic Waste Treatment - The JSC facility should construct an engineered septic tank with a suitable leach field to treat the domestic wastes generated by the facility Audit findings indicated that the current practices involved discharge of domestic wastes to an open excavation

  Technical Feasibility Evaluation A preliminary engineering evaluation for this effort determined that the existing septic tank was operating correctly and did not require modification

4 1 3 3 *Waste Collection Basin*

Although the waste collection basin does not "generate" wastes, the proper operation of this unit is critical to the prevention of pollution at the JSC facility The following PP/WM opportunities are provided to ensure proper operation of the basin

- Optimize Operation of the Collection Basin - The JSC facility should carefully study the operation of the waste collection basin to ensure that wastewater does not leak or drain from the basin to the ground or to the wadi Information provided by the JSC facility indicated that the net discharge to the basin, accounting for evaporation (10 mm/day), was over 6,000 $m^3$/yr Because the total capacity of the basin is only 4,350 $m^3$, and because the basin has been in operation since 1990, a considerable volume of wastewater is unaccounted for

  Technical Feasibility Evaluation The optimization of the collection basin will require JSC staff to carefully monitor and document the performance of the basin over several months of operation Flow monitoring devices should be installed, and logs should be maintained, to accurately track flow in to and out of the basin Based on the results of this evaluation, the performance of the basin would be evaluated, and a determination of the potential for leakage could be made

  The implementation of this alternative would require the installation of flow monitoring devices, and would require some additional staff time to track performance

- Prevent Seepage from the Collection Basin - The JSC facility should evaluate the possible migration of wastewater from the basin to the soil and groundwater To perform the evaluation, monitoring wells should be constructed near the basin to determine if leakage has occurred, and if so, the extent of the migration



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**Technical Feasibility Evaluation** The implementation of this alternative would require the establishment of a series of monitoring wells near the waste collection basis At a minimum, 3 wells should be placed around the basin, particularly in the area between the basin and the wadi to determine if seepage has occurred A topographical map indicating the suggested location of the wells is provided in Appendix B of this report

In its letter of July 5, 1995, the JSC facility indicated that although the waste collection basin had been constructed under the supervision of government authorities, JSC continued to monitor its operation to ensure that no leakage has occurred

A general assessment of the local hydrogeological conditions, provided by MWI, indicated that the depth to the upper aquifer was approximately 60 m The geology in the immediate vicinity of the JSC facility has not been fully explored, however, it consists primarily of limestones, chalky limestones, marls and clays Geological features including cracks and flexures intersperse the area and generally control the movement of groundwater Since hydrogeological information for the area immediately surrounding the JSC facility was not available, and because no estimate of potential leakage from the basin had been developed, an evaluation of the potential for groundwater contamination was not developed for this report It is likely, however, that contaminants in the upper, unsaturated, soils near the JSC facility, would be flushed toward the wadi during a storm event.

## 4 2 TECHNICAL FEASIBILITY OF WATER CONSERVATION TECHNIQUES

In general, the opportunities for water conservation identified for the JSC facility could be arranged in three general categories

- Process Control,
- Cooling and Boiler Water, and
- Floor Wash and Cleaning Activities

The water conservation opportunities identified for each of the categories are provided in the following sections Following the presentation of each alternative, a summary of the technical feasibility of developing and implementing the alternative is provided Where engineering analyses were required to conduct the feasibility analysis, the supporting documentation is referenced in the appendices of this report

### 4 2 1 Process Control

A number of water conservation opportunities, related to the manufacturing processes at the JSC facility, were identified by the audit team The opportunities identified in this category involve water uses related directly to specific production plant operations Water conservation techniques identified in this section included general activities, such as leak prevention and maintenance, as well as specific process modifications



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Sulfonation/Sulfation

- Leak Prevention - JSC should provide additional maintenance to prevent or repair leaks as soon as possible The audit identified several leaks within the sulfonation plant that were collecting and draining to the collection basin Based on information provided by the facility, 0 5 $m^3$/day could be attributed to leaks, spills and floor washing Assuming that 25 percent of this flow is attributed to leaks, and that these leaks could be reduced by 50 percent, this would result in a water savings of 0 06 $m^3$/day

  **Technical Feasibility Evaluation** (See Section 4 1 1)

- Elimination of Contact Cooling for Sulfur Pumps - Contact cooling water for sulfur pumps should be replaced by a non-contact cooling water system or use of sealless pumps Although the current contact cooling water flow is low, the water used for this purpose is not necessary Based on the current flow estimates, this would result in a water savings of 0 1 $m^3$/day

  **Technical Feasibility Evaluation** For a discussion of the use of sealless pump, see Section 4 1 1

- Minimization of Scrubber Water - The JSC facility should maximize the air to water ratio in the scrubber unit in order to minimize water use necessary for this unit to operate effectively Based on current flow estimates, approximately 7 $m^3$/day of spray water is used by the unit

  **Technical Feasibility Evaluation.** The optimization of this process will require JSC staff to carefully monitor and document the use of water in the scrubber unit under various operating conditions Logs should be developed to accurately track operating parameters versus $SO_2$ emissions to identify optimum performance Based on the results of this analysis, the unit would then be closely monitored to ensure that optimum conditions are maintained

Saponification

- Leak Prevention/Condensate Reuse - JSC should provide additional maintenance for the saponification process to prevent wasting of cooling water and steam condensate due to contamination Currently, contamination by soap is requiring wasting of 1 $m^3$/day of cooling water and condensate to the collection basin instead of returning it to the condensate recovery system Assuming that leak maintenance would reduce the required wasting by 75 percent, this would result in the elimination of the need for 0 75 $m^3$/day of make-up water

  **Technical Feasibility Evaluation** (See Section 4 1 1)

Sodium Silicate Production

- Elimination of Contact Cooling for Casting Belt - Contact cooling of casting belt should be replaced by a non-contact system Current practice results in evaporative loss of about 7 $m^3$/day and a discharge to the collection basin of about 7 $m^3$/day (approximately 16 percent of total facility consumption) Assuming that a non-contact system would reduce this by approximately 75 percent, this would save 11 $m^3$/day, or about 12 percent of the total water consumed at the JSC facility

  **Technical Feasibility Evaluation** (See Section 4 1 1)

- Maximization of Cooling Water Reuse - The JSC facility should maximize its use of the casting belt cooling water for dissolution of rock sodium silicate This would result in the need for less make-up water, and less overall water use, in the sodium silicate production and dissolution plant

  **Technical Feasibility Evaluation** The optimization of the use of the cooling water would require JSC staff to carefully monitor and document the use of water in the dissolution process Logs should be developed to accurately track water use and discharge to ensure the maximum reuse of this resource

STS Production

- Process Water Reuse - JSC should recycle all water following toluene recovery and reduce the need for fresh make-up water Current practices identified during the audit indicated a discharge of 0 07 $m^3$/day of toluene contaminated process water Recycling of this stream, therefore, would eliminate the need for 0 07 $m^3$/day of fresh water

  **Technical Feasibility Evaluation** (See Section 4 1 1)

- Cooling Water Segregation - The cooling water system for the STS plant should be segregated from the central cooling system to prevent contamination Current practice requires periodic blowdown of central cooling system due, in part, to toluene contamination Complete refilling of the cooling system requires approximately 50 $m^3$ of fresh water Assuming that the need for complete refilling of the system due to toluene contamination occurs once every 3 weeks a water savings of 2 4 $m^3$/day would be achieved

  **Technical Feasibility Evaluation** (See Section 4 1 1)

- Dryer Condensate Reuse - The JSC facility should investigate possible in-plant uses, such as equipment or floor cleaning, for the condensed vapors from the STS drying unit The wastestream was discharged to the collection basin, however, it was relatively clean, containing approximately 3 percent STS Assuming 25 percent of the condensate could be used in place of fresh water, a water savings of approximately 0 21 $m^3$/day would be anticipated

  **Technical Feasibility Evaluation** The implementation of this alternative does not require an engineering analysis, however, staff time will be required to evaluate potential uses of this wastestream

4 2 2 Cooling and Boiler Water

Additional water conservation opportunities were identified by the audit team for the central cooling and boiler systems These opportunities included

- Pre-treatment of Cooling Water - The JSC facility should use RO water or softened water for cooling water make-up Current practice used untreated well water, or tanker water, containing high TDS As water was lost from the system, TDS concentrations increased and resulted in frequent blowdown Use of treated water would decrease blowdown frequency and reduce the need for make-up water The JSC facility estimates that 1 $m^3$/day is sent to the basin as blowdown Assuming a 50 percent reduction in the need for blowdown due to use of pre-treated make-up water, a savings of 0 5 $m^3$/day would be expected

  **Technical Feasibility Evaluation** The implementation of this alternative would not require an engineering analysis, however, water use should be closely monitored by JSC staff to determine if this practice results in significant savings

  Based on comments provided by the JSC facility, alternative sources of water will be identified in order to eliminate the use of the on-site well, thus, this alternative will not be necessary

- Maximization of Heat Recovery - All means should be investigated for heat recovery prior to release of any waste gases/steam to the atmosphere This may result in conservation of energy and reduce water consumption through the need for less make-up water for steam generation

  **Technical Feasibility Evaluation.** The implementation of this alternative would not require an engineering analysis, however, heat loss and heat recovery should be closely monitored by JSC staff to determine if savings can be achieved

- Reduction of Steam Losses - The JSC facility should provide additional maintenance to prevent steam leaks Evaporative losses are estimated to be approximately 33 $m^3$/day throughout the facility Assuming a 15 percent reduction due to improved maintenance, a savings of 5 $m^3$/day would be anticipated

  **Technical Feasibility Evaluation** The implementation of this alternative would not require an engineering analysis, however, steam losses and vapor recovery should be closely monitored by JSC staff to determine if this savings can be achieved

4 2 3 Floor Wash and Cleaning Activities

The audit team identified several opportunities for water conservation related to general cleaning and maintenance activities The following suggestions are provided

- Floor Washing and Equipment Cleaning - The JSC facility indicated that approximately 2 $m^3$/day of fresh water was used for floor washing and equipment cleaning activities throughout all plant areas The audit team observed that low pressure hoses were used for simple cleaning tasks The JSC facility should replace the low pressure hoses with a high pressure system Assuming that the high pressure system would reduce overall cleaning water use by 15 percent, a savings of 0 3 $m^3$/day would be anticipated



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**Technical Feasibility Evaluation** The implementation of this alternative would require installation of a plant wide high pressure water line, or the installation of pressure pumps in various sections of the plant Design and installation of a system for this purpose will require significant contributions of JSC staff time

- Truck Cleaning - The JSC facility should provide additional draining of product prior to washing tankers, and use a high pressure washing system to reduce water use Truck cleaning operations at the JSC facility used approximately 2 $m^3$/truck, and washed approximately 120 trucks per year This resulted in a fresh water consumption of about 0 8 $m^3$/day Assuming that the additional draining time, and use of high pressure hoses would result in a 50 percent reduction in water use, a savings of 0 4 $m^3$/day would be expected

  **Technical Feasibility Evaluation** The implementation of this alternative would require installation of a high pressure water line, or the installation of pressure pumps in the truck wash area Design and installation of a system for this purpose will require significant contributions of JSC staff time

  Based on comments provided by the JSC facility, the practice of washing trucks and barrels on-site has been significantly curtailed Therefore, this alternative is no longer applicable



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# 5.0

# OPPORTUNITY COST/BENEFIT ANALYSIS

# 5.0 OPPORTUNITY COST/BENEFIT ANALYSIS

In addition to the technical feasibility evaluation described in Section 4 0, each of the PP/WM and water conservation opportunities were evaluated to assess whether the alternative was appropriate based on projected costs and benefits In many cases, quantification of the costs and benefits was not possible due to data gaps and other uncertainties In these instances, a qualitative assessment is provided

## 5 1 COST/BENEFIT EVALUATION FOR POLLUTION PREVENTION/WASTE MINIMIZATION TECHNIQUES

As in Section 4 0 of the report, the PP/WM opportunities identified for the JSC facility could be arranged in three general categories

- Process Control,
- Materials Handling and Storage, and
- Control of Other Waste Generating Activities

The PP/WM opportunities identified for each of the categories (and described in the corresponding subsections of Section 4 0) are listed below For each alternative, a discussion of the cost/benefit of developing and implementing the alternative is provided Where engineering analyses were required to conduct the feasibility analysis, the supporting documentation is referenced in the appendices of this report

### 5 1 1 Cost/Benefit of Process Control Opportunities

The cost and benefit(s) anticipated for each of the process control PP/WM opportunities are provided in this section Please refer to Section 4 1 1 for a more detailed description of the alternatives

Sulfonation/Sulfation

- Reduction in Use of Branched Alkylbenzene - Cost effective

  No capital or implementation costs The only potential cost is the lost opportunity cost related to the loss in sales of the branched alkylbenzene product

- Sulfonator Optimization - Not Applicable

  Based on comments provided by JSC, the reactor is fully optimized, thus, there is no cost or benefit

- Utilization of Sealless Pump - Cost effective

  This alternative would require purchase of a sealless pump and would require minor piping modifications The benefit would be reduced contamination of the cooling water



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Based on comments provided by JSC, a replacement pump has been purchased, and cooling water is now segregated from the waste stream, thus, there will be no additional costs or benefits

- Leak Control - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

- Spill Prevention - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to improve handling procedures and increase maintenance Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

- Sulfur Quality Control - Not cost effective

  Use of a higher grade of sulfur would require JSC to identify new suppliers of sulfur located further away from the manufacturing facility This would likely result in significantly higher unit costs As the current sulfur supply meets JSC's specifications, and because JSC reports that utilization of the current sulfur can be improved through process modification, this alternative does not appear to be cost effective at the current time

- Catalytic Converter Optimization - Unknown

  The optimization procedures will not require any capital expenditures, and will not require significant staff time to implement If successful, the effort will result in a discharge reduction, however, a quantitative assessment cannot be developed at this time

Saponification

- Reactor Optimization - Not applicable

  Based on comments provided by JSC, the reactor is fully optimized, thus, there is no cost or benefit

- Leak Control - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks

- Production Schedule Optimization - Not applicable

  Based on comments provided by JSC, the current production schedule cannot be modified due to market and customer considerations In addition, JSC has implemented procedures to utilize a portion of the waste material generated during product changeover

Sodium Silicate Production

- Elimination or Minimization of Contact Cooling - Cost effective

  The engineering evaluation determined that the elimination of contact cooling water was not technically feasible, however, repositioning of the existing water spray jets would result in less contamination of the cooling water stream This modification could be performed by JSC staff at little or no cost The benefits would include lower solids contamination of the cooling water stream, increased potential for recycling of the cooling water stream, and less need for make-up water to replace cooling water previously discharged due to solids contamination

- Sediment/Filter Solids Control - Cost effective

  - Increasing the purity of raw materials - Cost effective

    JSC reports that it is working with suppliers to identify a higher quality silica sand that will result in lower waste generation The use of this material will not result in significant cost increase and will reduce the need for solid waste disposal Specific cost/benefit estimates are not possible without additional data regarding raw material quality

  - Optimizing the operation of the kiln - Unknown, unless the feasibility is assessed by JSC staff

    The optimization procedures will not require any capital expenditures, and will not require significant staff time to implement However, it is not possible to determine whether the optimization effort will result in measurable benefits

  - Optimizing the dissolving conditions in the autoclave - Unknown, unless the feasibility is assessed by JSC staff

    The optimization procedures will not require any capital expenditures, and will not require significant staff time to implement However, it is not possible to determine whether the optimization effort will result in measurable benefits

- Dust Control - Cost effective

  This alternative would require purchase of dust suppression equipment and would require minor process modifications The benefit would be reduced generation and dispersion of harmful silica dust

  Based on comments provided by JSC, dust suppression equipment has been purchased and will be installed in the near future, thus, there will be no additional costs or benefits



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Sodium Toluene Sulfonate Production

- Elimination of Toluene Discharge - Cost effective

  Based on the engineering evaluation performed for this alternative (see Appendix A), the following capital costs (not including labor) were projected

  - Repair concrete slab and install anti-acid and regular floor tiles (6,020 JD)
  - Collection pit and stainless steel tank (400 JD)
  - Submersible pump (200 JD)
  - 12 $m^3$ stainless steel tank and piping (1000 JD)
  - Holding tank, pump, and piping (700 JD)
  - Activated carbon filter (685 JD)
  - Pump from storage tank to activated carbon filter (200 JD)
  - Treated water storage tank (180 JD)
  - Concrete platform (300 JD)
  - Installation (9,685 JD)

  TOTAL COST = 19,370 JD = $27,118 US

  The benefit derived from this investment would be significant reductions in the quantity of toluene discharged to the waste collection basin A specific estimate of the reduction in toluene discharge could not be determined because toluene losses are not measured for this process However, preventing toluene contamination of the wastewater stored in the waste collection basin is considered a significant benefit

- STS Cooling Water Segregation - Not applicable

  Based on the engineering analysis described in Section 4 0, the segregation of the cooling system for the STS facility was determined to be impractical, and would provide little if any benefit

- Leak Control - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks

Alkanolamides Production - Cost effective

No capital cost The only cost associated with the alternative would be the additional staff time to drum and handle the pasty wastes Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits



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5 1 2 Cost/Benefit of Materials Handling and Storage

The cost and benefit(s) anticipated for each of the materials handling and storage PP/WM opportunities are provided in this section Please refer to Section 4 1 2 for a more detailed description of the alternatives

1 Containment of loading and unloading areas - Cost effective

Fuel Oil Unloading Area The costs to implement this alternative include the following

- 10 m x 4 m concrete pad (700 JD)
- 10 m x 4 m corrugated steel cover (1500 JD)
- Modification of the fuel oil containment pit (200 JD)
- Extension of trench line and installation of manhole (400 JD)
- Purchase of oil/water separator (1000 JD)
- Installation (3,800 JD)

TOTAL COST = 7,600 JD = $10,640 US (excluding labor)

The benefit derived from the implementation of this alternative include the reduced contamination of soil in loading and unloading area, reduced discharge of waste oil to the waste collection basin, and the recovery of fuel oil for use or sale

Loading Area for Raw Materials and Products Near the Sulfonation Plant The costs to implement this alternative include only the cost of the 12 m x 11 m concrete pad for approximately 3,500 JD ($4,900 US) The benefit derived from this alternative include reduced contamination of soil in loading area and reduced discharge of contaminated wastewater to the waste collection basin

Fatty Acid Tanker Unloading Area (above the STS Plant) The costs to implement this alternative include only the cost of the 18 m x 6 m concrete pad, with rain water collection trench and holding pit, for approximately 5,000 JD ($7,000 US) The benefit derived from this alternative include reduced contamination of soil in loading area and reduced discharge of contaminated wastewater to the waste collection basin

Fatty Acid Drum Unloading Area (between toluene storage tanks and the STS Plant) The costs to implement this alternative include only the cost of the steam jacket for the melting tank While a specific estimate was not calculated, the cost would not be significant The benefit derived from this alternative include reduced contamination of soil in loading area and reduced discharge of contaminated wastewater to the waste collection basin

2 Containment of storage areas - Cost effective

The total cost of the storage areas, as described in Section 4 0, would be approximately 9,000 JD ($12,600 US) While this cost is significant, the current drum and solid waste storage practices at the JSC facility were identified during the audit as the most significant pollution concern

Benefits associated with construction and use of storage facilities include, reduction of plant-wide soil contamination due to current material storage and disposal practices, reduction of potential for spills and accidents due to current drum storage, reduction in contamination of ground and surface water due to seepage and storm runoff

Based on comments received from the JSC facility, plans and designs have been developed for new storage facilities at the site, however, construction has not yet been initiated

3 Elimination of drainage hole in sulfur melting room and clean-up of solid waste - Cost effective

Repair of the hole will require construction of a small concrete patch in the wall of the sulfur melting room The cost for this patch should not exceed 100 JD ($140 US) The benefit of this repair is the elimination of sulfur discharge to bare ground

4 Dry clean-up of leaks and spills and maintenance of overflow collectors - Cost effective

No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

5 Maintenance and operation of existing containment structures - Cost effective

No capital cost The only cost associated with the alternative would be the additional staff time to maintain containment structures and to ensure proper procedures are developed and followed The primary benefit of properly maintained and operated containment structures is the containment of spills and the prevention of uncontrolled discharged to the collection basin or wadi

6 Elimination of tanker truck and barrel washing - Cost effective

No capital cost Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

5 1 3 Cost/Benefit for Control of Other Waste Generating Activities

The cost and benefit(s) anticipated for PP/WM opportunities related to other waste generating activities are provided in this section Please refer to Section 4 1 3 for a more detailed description of the alternatives

5 1 3 1 *Solid and Drummed Wastes*

- Utilization of Sulfur Wastes - Cost effective

No capital or labor costs Benefits include reduced solid waste disposal costs, and potential cost recovery from previously discarded material Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits



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- Utilization of Charred Material - Cost effective

  No capital or labor costs Benefits include reduced solid waste disposal costs, and potential cost recovery from previously discarded material Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

- Utilization of Sodium Silicate Sediment - Cost effective

  No capital or labor costs Benefits include reduced solid waste disposal costs, and potential cost recovery from previously discarded material Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

- Utilization of Sodium Sulfate Wastes - Cost effective

  No capital or labor costs Benefits include reduced solid waste disposal costs, and potential cost recovery from previously discarded material Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

5 1 3 2 *Utilities Wastes*

- Utilization of RO Reject - Not applicable

  The JSC facility indicated that it intended to use source of water other than its on-site wells Therefore, the RO unit will not be used

- Utilization of Recovered Fuel Oil - Cost effective

  The oil/water separator used to recover contaminated fuel oil was costed in Section 5 1 2, above The benefits include reduced discharge of waste oil to the waste collection basin, and the potential recovery of oil for use or sale

- Leak and Spill Prevention - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs or benefits

- Domestic Waste Treatment - Not applicable

  Based on a preliminary engineering analysis, the current septic tank system is appropriate



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5 1 3 3 *Waste Collection Basin*

- Optimize Operation of the Collection Basin - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to monitor and maintain the basin

- Prevent Seepage from the Collection Basin - Unknown

  The implementation of this alternative requires the construction of 3 monitoring wells in the vicinity of the waste collection basin (see Appendix B) The cost associated with well construction were not estimated, but are not anticipated to be significant The benefit associated with this effort is the assurance that the basin is operating properly, and that seepage is not contaminating groundwater in the area

## 5 2 COST/BENEFIT EVALUATION OF WATER CONSERVATION TECHNIQUES

As in Section 4 0 of the report, the opportunities for water conservation are identified for the JSC facility could be arranged in three general categories

- Process Control,
- Cooling and Boiler Water, and
- Floor Wash and Cleaning Activities

The water conservation opportunities identified for each of the categories (and described in the corresponding subsections of Section 4 0) are listed below For each alternative, a discussion of the cost/benefit of developing and implementing the alternative is provided Where engineering analyses were required to conduct the feasibility analysis, the supporting documentation is referenced in the appendices of this report

### 5 2 1 Cost/Benefit of Process Control Alternatives

The cost and benefit(s) anticipated for water conservation opportunities related to process control are provided in this section Please refer to Section 4 2 1 for a more detailed description of the alternatives

Sulfonation/Sulfation

- Leak Prevention - Cost effective (see Section 5 1 1)

  Implementation could result in a water savings of approximately 0 06 $m^3$/day

- Elimination of Contact Cooling for Sulfur Pumps - Cost effective (see Section 5 1 1)

  Implementation could result in a water savings of approximately 0 1 $m^3$/day



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- Minimization of Scrubber Water - Unknown

  The optimization procedures will not require any capital expenditures, and will not require significant staff time to implement If successful, the effort will result in a slight water savings

Saponification

- Leak Prevention/Condensate Reuse - Cost effective (See Section 5 1 1)

  Implementation could result in a water savings of approximately 0 75 $m^3$/day

Sodium Silicate Production

- Minimization of Contact Cooling for Casting Belt - Cost effective (see Section 5 1 1)

  As discussed in Section 4 1 1, the elimination of contact cooling was not technically feasible for this process Instead, process modifications were suggested to reduce cooling water contact Implementation could result in a water savings of perhaps 10 percent or 1 4 $m^3$/day

- Maximization of Cooling Water Reuse - Cost effective (see Section 5 1 1)

  Based on the process modification of the contact cooling water system, the recovered cooling water should contain less contamination thereby allowing a longer detention time in the recirculation system This could result in a savings of perhaps 1 $m^3$/day

STS Production

- Process Water Reuse - Cost effective (See 5 1 1)

  Implementation of this alternative should result in a water savings of 0 07 $m^3$/day

- Cooling Water Segregation - Not applicable (See Section 5 1 1)

  The engineering analysis determined that toluene contamination of the closed loop cooling water system was not a problem, thus, no water savings would be realized for this alternative

- Dryer Condensate Reuse - Unknown

  No capital cost The only cost associated with this alternative is the staff time to evaluate the potential uses for the condensate The benefit would be the recovery of approximately 0 21$m^3$/day of water

5 2 2 Cost/Benefit of Cooling and Boiler Water Alternatives

The cost and benefit(s) anticipated for water conservation opportunities related to cooling and boiler water are provided in this section Please refer to Section 4 2 2 for a more detailed description of the alternatives



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- Pre-treatment of Cooling Water - Not applicable

  The JSC facility indicated in its letter of July 5, 1995, that it intended to use a water supply other than its on-site wells The use of the cleaner water supply will eliminate the need to pre-treat the cooling water supply

- Maximization of Heat Recovery - Unknown

  No capital cost The only cost associated with this alternative is the staff time to maximize the efficiency of the steam generation and circulation system It is not possible to quantify the benefits of this alternative due to the absence of data regarding steam generation and losses

- Reduction of Steam Losses - Cost effective

  No capital cost The only cost associated with the alternative would be the additional staff time to maintain equipment and repair leaks Based on comments provided by JSC, this alternative has already been implemented, thus, there will be no additional costs If steam losses are reduced by 15 percent, a water savings of 5 $m^3$/day could be realized

5 2 3 Cost/Benefit of Floor Wash and Cleaning Activities

The cost and benefit(s) anticipated for water conservation opportunities related to floor washing and equipment cleaning are provided in this section Please refer to Section 4 2 3 for a more detailed description of the alternatives

- Floor Washing and Equipment Cleaning - Unknown

  Capital costs would include the installation of a high pressure water system, and the purchase and use of pressure nozzles on hoses throughout the JSC facility Since the potential water savings is only 0 3 $m^3$/day, it is unlikely that this effort would be cost effective

- Truck Cleaning - Cost effective

  No capital costs Based on information provided by JSC, truck and barrel washing have either been eliminated, or reduced to very low levels, thus, no costs are anticipated Water savings of 0 4 to 0 8 $m^3$/day should be realized through this process change



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# 6.0

# CONCLUSIONS AND RECOMMENDATIONS

## 6 0 CONCLUSIONS AND RECOMMENDATIONS

Based on the technical feasibility evaluation (Section 4 0) and the cost benefit analysis (Section 5 0), recommendations are provided in this section regarding each of the PP/WM and water conservation opportunities The findings and recommendations are summarized in tabular form, and identified whether the alterative was "technically feasible," "cost effective," and whether or not it is recommended by the FS team as a viable alternative

### 6 1 RECOMMENDATIONS FOR POLLUTION PREVENTION/WASTE MINIMIZATION TECHNIQUES

The conclusions and recommendations regarding PP/WM alternatives are provided in Tables 6-1, 6-2, and 6-3

**Table 6-1 Evaluation of Process Control PP/WM Opportunities**

| Process Control Opportunity | Technically Feasible? (Yes/No) | Cost Effective? (Yes/No) | Alternative Recommended? (Yes/No) |
|---|---|---|---|
| Sulfonation/Sulfation | | | |
| Reduction in Use of Branched Alkylbenzene | Yes | Yes | Yes |
| Sulfonator Optimization | No | N/A | No |
| Utilization of Sealless Pump | Yes | Yes | Yes |
| Leak Control | Yes | Yes | Yes |
| Spill Prevention | Yes | Yes | Yes |
| Sulfur Quality Control | Yes | No | No |
| Catalytic Converter Optimization | Yes | Unknown | Yes |
| Saponification | | | |
| Reactor Optimization | No | N/A | No |
| Leak Control | Yes | Yes | Yes |
| Production Schedule Optimization | No | N/A | No |
| Sodium Silicate Production | | | |
| Elimination or Minimization of Contact Cooling | Yes | Yes | Yes |
| Sediment/Filter Solids Control | Yes | Yes | Yes |
| - Increasing the purity of raw materials | Yes | Yes | Yes |
| - Optimizing the operation of the kiln | Yes | Yes | Yes |
| - Optimizing the dissolving conditions in the autoclave | Yes | Yes | Yes |
| Dust Control | Yes | Yes | Yes |



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| Table 6-1 Evaluation of Process Control PP/WM Opportunities | | | |
|---|---|---|---|
| **Process Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Sodium Toluene Sulfonate Production | | | |
| Elimination of Toluene Discharge | Yes | Yes | Yes |
| STS Cooling Water Segregation | No | N/A | No |
| Leak Control | Yes | Yes | Yes |
| Alkanolamides Production | | | |
| Drum all pasty wastes | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement the alternative

| Table 6-2 Evaluation of Materials Handling and Storage PP/WM Opportunities* | | | |
|---|---|---|---|
| **Materials Handling and Storage Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Containment of loading and unloading areas | Yes | Yes | Yes |
| Containment of storage areas | Yes | Yes | Yes |
| Elimination of drainage hole in sulfur melting room and clean-up of solid waste | Yes | Yes | Yes |
| Dry clean-up of leaks and spills and maintenance of overflow collectors | Yes | Yes | Yes |
| Maintenance and operation of existing containment structures | Yes | Yes | Yes |
| Elimination of tanker truck and barrel washing | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement, the alternative



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| Table 6-3 Evaluation of PP/WM Opportunities for Control of Other Waste Generating Activities* | | | |
|---|---|---|---|
| **Other Waste Generation Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Solid and Drummed Wastes | | | |
| Utilization of Sulfur Wastes | Yes | Yes | Yes |
| Utilization of Charred Material | Yes | Yes | Yes |
| Utilization of Sodium Silicate Sediment | Yes | Yes | Yes |
| Utilization of Sodium Sulfate Wastes | Yes | Yes | Yes |
| Utilities Wastes | | | |
| Utilization of RO Reject | N/A | N/A | N/A |
| Utilization of Recovered Fuel Oil | Yes | Yes | Yes |
| Leak and Spill Prevention | Yes | Yes | Yes |
| Domestic Waste Treatment | N/A | N/A | N/A |
| Waste Collection Basin | | | |
| Optimize Operation of the Collection Basin | Yes | Yes | Yes |
| Prevent Seepage from the Collection Basin | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented, or has begun to implement, the alternative

## 6 2 RECOMMENDATIONS FOR WATER CONSERVATION TECHNIQUES

The conclusions and recommendations regarding water conservation alternatives are provided in Tables 6-4, 6-5, and 6-6

| Table 6-4 Evaluation of Water Conservation Opportunities for Process Control | | | |
|---|---|---|---|
| **Process Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Sulfonation/Sulfation | | | |
| Leak Prevention | Yes | Yes | Yes |
| Elimination of Contact Cooling for Sulfur Pumps | Yes | Yes | Yes |
| Minimization of Scrubber Water | Yes | Unknown | Yes |
| Saponification | | | |
| Leak Prevention/Condensate Reuse | Yes | Yes | Yes |



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| Table 6-4 Evaluation of Water Conservation Opportunities for Process Control | | | |
|---|---|---|---|
| **Process Control Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Sodium Silicate Production | | | |
| Minimization of Contact Cooling for Casting Belt | Yes | Yes | Yes |
| Maximization of Cooling Water Reuse | Yes | Yes | Yes |
| STS Production | | | |
| Process Water Reuse | Yes | Yes | Yes |
| Cooling Water Segregation | No | N/A | No |
| Dryer Condensate Reuse | Yes | Unknown | Yes |

* Shaded cell indicates that JSC has already implemented, or has begun to implement, the alternative

| Table 6-5 Evaluation Water Conservation Opportunities for Cooling and Boiler Water | | | |
|---|---|---|---|
| **Cooling and Boiler Water Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Pre-treatment of Cooling Water | N/A | N/A | N/A |
| Maximization of Heat Recovery | Yes | Unknown | Yes |
| Reduction of Steam Losses | Yes | Yes | Yes |

* Shaded cell indicates that JSC has already implemented or has begun to implement, the alternative

| Table 6-6 Evaluation of Water Conservation Opportunities for Floor Wash and Cleaning Activities | | | |
|---|---|---|---|
| **Floor Wash and Cleaning Opportunity** | **Technically Feasible? (Yes/No)** | **Cost Effective? (Yes/No)** | **Alternative Recommended? (Yes/No)** |
| Floor Washing and Equipment Cleaning | Yes | Unknown | No |
| Truck Cleaning | N/A | N/A | N/A |

* Shaded cell indicates that JSC has already implemented, or has begun to implement, the alternative



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# Appendix A

## Preliminary Engineering Plans for the STS Facility

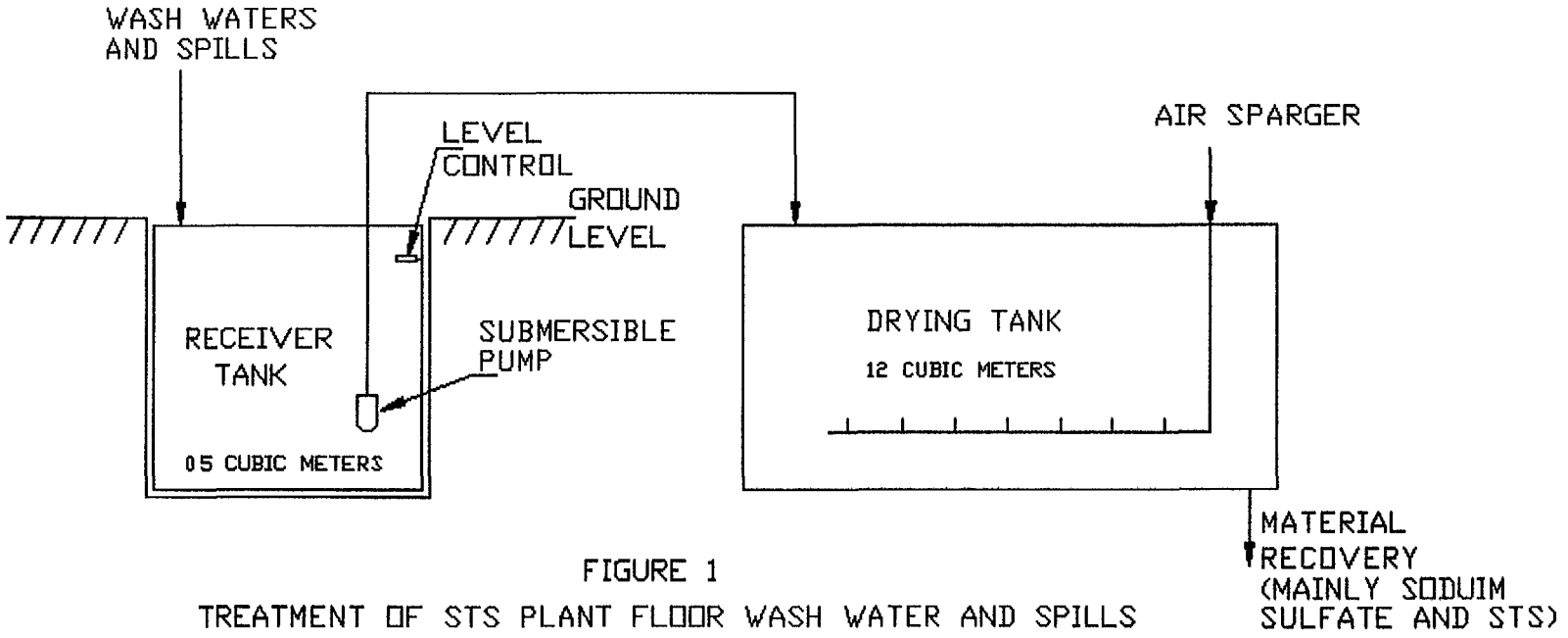


FIGURE 1

TREATMENT OF STS PLANT FLOOR WASH WATER AND SPILLS

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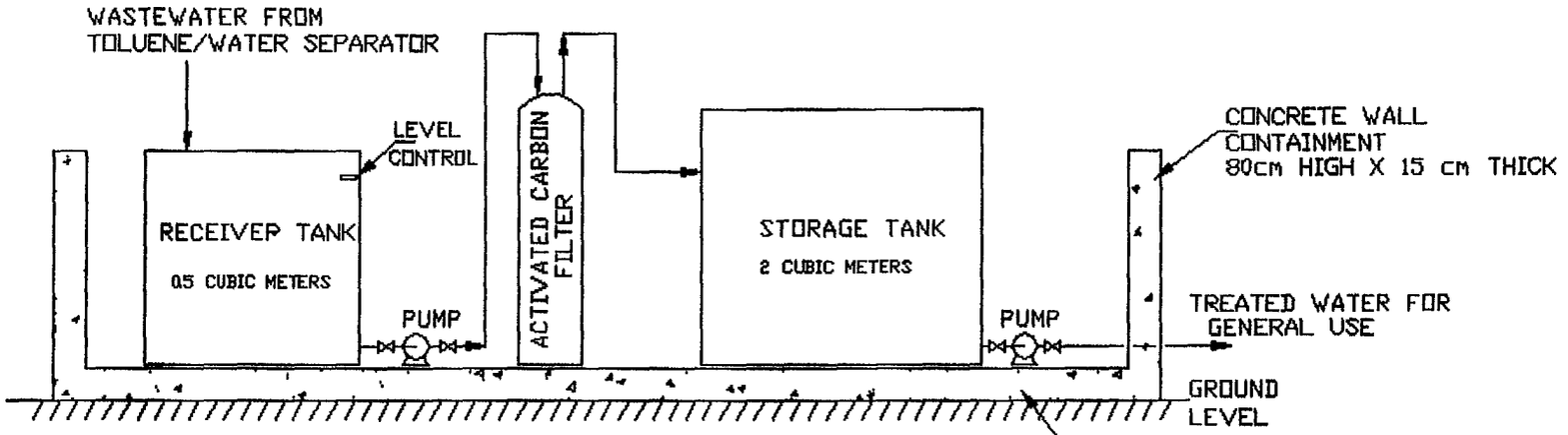
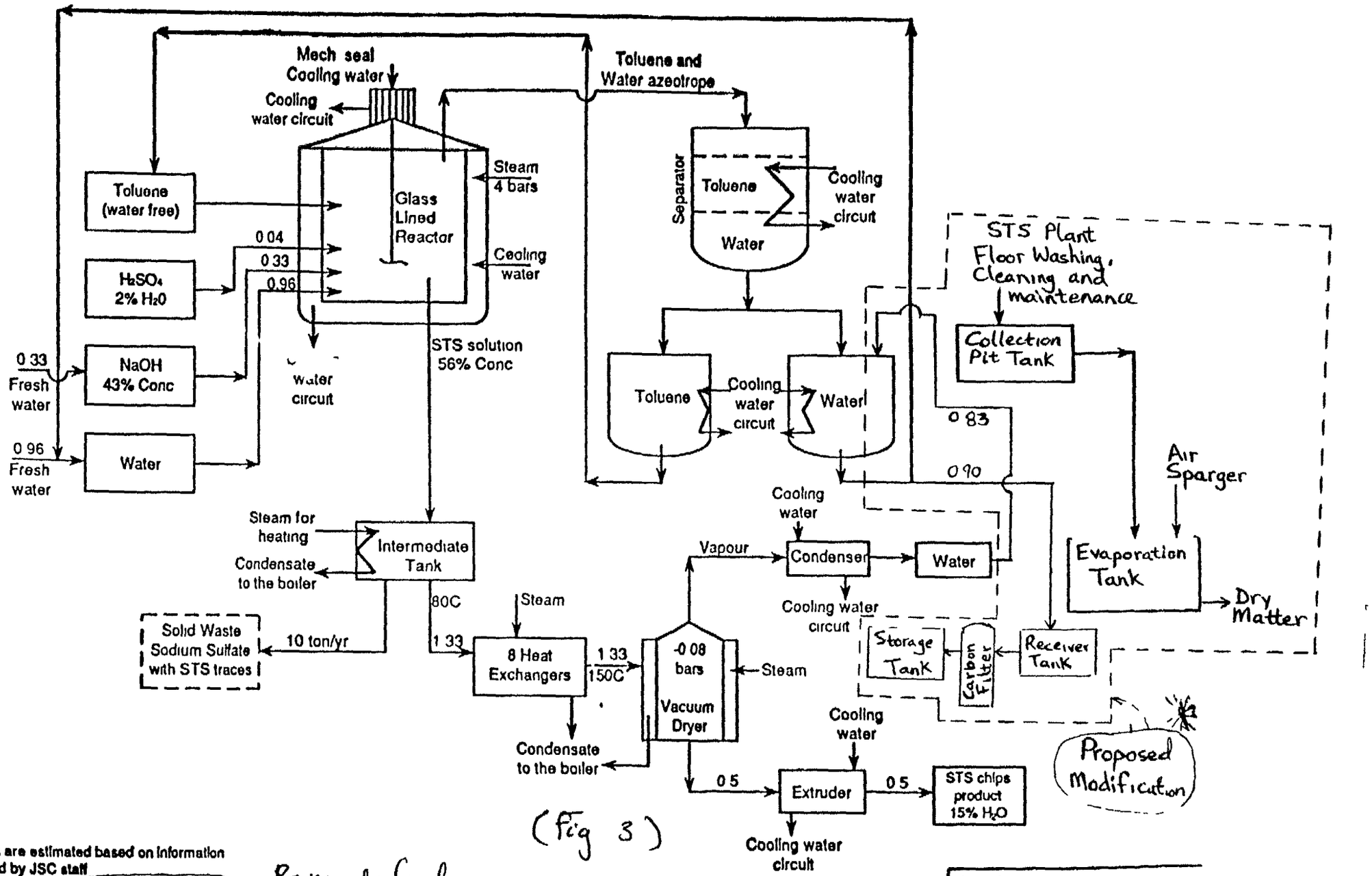



FIGURE 2

TREATMENT OF WASTEWATER STREAM FROM TOLUENE/WATER SEPARATOR




NOTES:
- All flows are estimated based on information provided by JSC staff
- Basis 7000 ton/yr of product, 300 days/yr

400 Ton/yr

**Figure 6 Process Flow Diagram of Sodium Toluene Sulfonate (STS) Production**
[illegible] Sulpho-Chemicals Company

شركة تكنولوجيا عالم المياه ذ م م
لمعالجة المياه والمياه العادمة
WORLD OF WATER TECHNOLOGY CO W L L
Water & Waste Water Treatment

**Date : June,27th,1995**
**REF.: W.W T.5165**
**ATT.: SULPHOCHEMICAL CO**

**Dear Sir,**

Thanking you for trusting us Your order has been having our immediate attention so it gives us pleasure to co-operatewith you

Our offer to your good self as follows -

**RAW WATER FEED/BACK WASH PUMP**

Raw water filter feed pump DRAW the water from the wast water storag tank and transfer it to the activated carbon filter

| | |
|---|---|
| 1- Model | JP5 - 220 volt - 1HP stainless steel pump GRUND FOS ( with float valve) |
| Capacity | up to 4 M /H |
| price | 130 JD |
| 2- Model | FBARA Submerible sump pump 220 volt |
| Capacity | up to 1,5 M³/H at head 7M |
| Price | 125 JD |

**AUTOMATIC ACTIVATED CARBON FILTER.**

The water will enter the carbon filter for removal of order taste, chlorine periopic back washing is required to eliminate accumalated suspenped matter and regard bed

| | |
|---|---|
| Model | 56F 10 10c AQuamatch (U S A ) |
| Excellen Service Flow Rate | 2 0GPM |
| High Service Flow Rate | 4 5 GPM |
| Peak (Max Flow Rate) | 8 0GPM |
| Back Wash Flow Rate | 5 GPM |
| Pipe Size | ¾" |
| Media CU FT | 1 CU FT |

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| | |
|---|---|
| Tank Size | 10" x 47" |
| Price | 685 JD |
| Interconnection pipework. cabels with a total price of | 130 JD |
| Validity | 4 Weeks |
| Delivery | Immediatly |

**Gurantee** for one year including any spare parts might be needed

We hope to hear from you about any development or special offer you may able to make and we hope that all the above will meet your requirements and approval

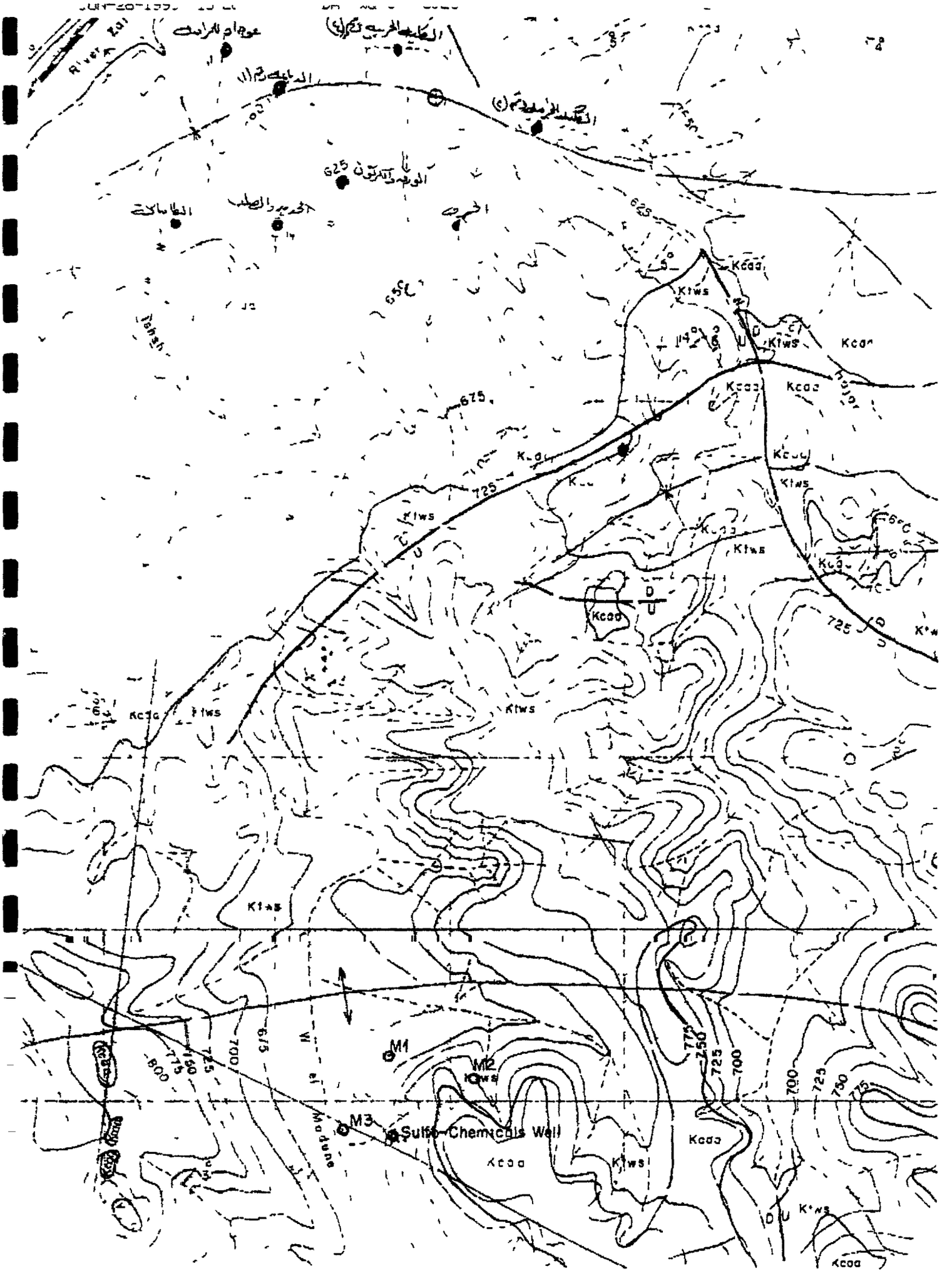
**Best Regards**

**Hasan Al-Zamat**

**Tech Manager.**

Appendix B

Proposed Location of Monitoring Wells

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