Research Article

The Role of Quality Assurance in Geological Investigations: A Case Study

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Abstract

Implementation of a Quality Assurance (QA) program in geological investigation is very significant and essential, especially when the investigation is carried out for selection and evaluation of strategic and vital project sites. The current work is a case study for selection and evaluation of a strategic site in Iraq where a QA program was implemented for the first time in the Iraq Geological Survey (as a Contractor) as a mandatory condition implied by the Client for all work carried out and included in the geological investigation. The geological investigation included six main activities: 1) geology, 2) hydrogeology, 3) geophysics, 4) engineering geology, 5) drilling and 6) laboratory work. The main roles of QA staff were to: 1) check the qualifications of all staff members involved in the six activities, 2) verify work procedures by means of which the staff members of each activity were performing their tasks, 3) follow-up all carried out works in the field, laboratory and office, 4) verify all types of work outputs by the staff members of the six activities, and 5) recognize any nonconformance in any type of carried out work before been recognized by the QA and/ or Quality Control (QC) staff of the Client. During the performance of the contract that lasted for 30 months, three nonconformance cases by the Contractor were recognized by the QA staff members and relevant corrective actions were performed. The three cases were not detected or recognized by the QA and QC staff members of the Client.

Keywords: Quality Assurance, Quality Control, Work Procedure, Nonconformance, QA.

1. Introduction

Quality Assurance (QA) is a way of preventing mistakes and defects in manufactured products and avoiding problems when delivering products or services to customers; which ISO 9000 defines as "part of quality management focused on providing confidence that quality requirements will be fulfilled". This defect prevention in QA differs subtly from defect detection and rejection in Quality Control (QC) and has been referred to as a shift left since it focuses on quality earlier in the process (Dr.Dobb's, 2001). QA includes management of the quality of raw materials, assemblies, products and components, services related to production, and management, production and inspection processes (Stebbing, 1993).

QA programs were previously implemented in strategic and/or vital projects, such as nuclear industry, aerospace, and aviation. However, since the last decade of the last century, QA programs have been implemented more widely in different industries where ISO 9000 was founded and later on was extended for use more widely.

Recently, QA programs areimplemented almost in all sectors of domestic life, such as industrial, economical, educational, transportation, agricultural, commercial, health, mineral exploration, geological investigation, etc. Therefore, the need of QA program implementation becomes almost compulsory to have good products and challenging ability by means of following ISO standards.

1.1. Aim

The aim of this work is to present the results of the implementation of a QA program by the current author with the assistance of one geologist. The QA program was implemented on a strategic project carried out by Iraq Geological

Survey (GEOSURV); as the Contractor during 1988 – 1991 in the central part of Iraq on behalf of the Client. In addition, the importance of the QA implementation on geological investigations; as a case study, is presented.

1.2. Location

The location of the strategic project is in the central part of Iraq within Salahideen Governorate, north of Baghdad. Four main sites were studied in order to evaluate and rank them, and to choose the best recommended site.

1.3. Previous Work

Implementation of QA programs in different scopes is very common; one of them is geological investigations. Few examples are presented: Sissakian (1991) reported about the implementation of a Quality Assurance program in a strategic project carried out by GEOURV. Geboy and Engle (2011) mentioned that the principal investigator of a scientific study ultimately is responsible for the quality and interpretation of the project's findings, and thus must also play a role in the understanding, implementation, and presentation of QA/QC information about the data. Plouffe et al. (2013) mentioned that quality assurance and quality control measures must be implemented to ensure that 1) in the field, samples are not contaminated from external sources or from other samples; 2) during sample processing and indicator mineral picking, loss of indicator mineral grains are minimized, cross-contamination before and among sample batches does not occur, and minerals are correctly identified; and 3) all reported indicator mineral data include adequate meta-data for future reference and comparison. Setyadil and Anggayana (2013) mentioned that part of the System management and Quality Assurance are the data validation, consolidation and reporting. Database developer should work closely with the field geologist/ explore to identify the potential data error for validation. On the other hand, the field geologist should have an awareness of the impact of the data error and how it should be prevented. The first time the field crews may be inconvenienced with several validation systems.

2. Materials and Methods

The main data used in this work is based on the data acquired from the implementation of a QA program in a strategic project that is documented by Sissakian (1991). However, MQA (1987) was used during the implementation of the QA program by the author. Many forms were used during the implementation of the program by the current author and the assistant. The original forms were acquired from MQA (1987); however, all those used forms were moderated by the current author to meet with the requirements of performing a QA program in the strategic project.

2.1. Forms

To perform the QA program in the strategic project, eleven different types of forms were used. The numbers of each 11 types are presented in Table 1. The forms used are briefly mentioned hereinafter.

Table 1. Types of different forms used in the strategic project.

No.	Activity Name	Experience Form	Training plan		Calibration Form	Work Progress Forms			Work Completion Form	Verification Form	Committee Meeting Form	Reviewing Committee Form	Nonconformance Form
			Passed	Failed		Filed Work	Office Work	Laboratory Work					
1	**Project Management**	2	-	-	-	-	-	-	-	-	-	-	-
2	**Geology**	21	6	2	-	350	138	-	6	10	8	5	-
3	**Geophysics**	24	11	1+1*	6	230	106	-	10	8	4	4	-
4	**Hydrogeology**	20	10	1	1	281	72	-	26	10	5	4	1
5	**Eng. Geology**	9	4	1	-	258	29	10	12	7	4	3	-
6	**Drilling**	26	4	-	-	342	-	-	17	14	4	-	1
7	**Laboratories**	33	10	-	8	100	4	363	25	18	5	3	1
8	**Q. A. Unit**	2	1	-	-	-	-	-	-	-	1	1	-
Total		**137**	**46**	**6**	**15**	**1561**	**349**	**373**	**96**	**67**	**31**	**20**	**3**

***** *One of the trainees did not complete the training. The number of the total staff members is 141 (139 besides the Project Manager and the deputy).*

2.1.1. Experience form

For all staff members of the strategic project, an experience form was prepared; even for the Project Manager and the deputy, see Table 1. The scientific degree, job title and years of experience are mentioned in the form. In total, 141 forms were filled in.

2.1.2. Training Form

Staff members who lacked experience and were not qualified to join the work in the strategic project, were directed to take training programs that were prepared by the the one responsible for the activity under supervision of the QA Unit. In total, 53 forms were filled; however, among them 6 of the staff failed the training and were not allowed to join the project, see Table 1.

2.1.3. Calibration Form

All equipment used in the project was subjected to calibration when needed. The details of calibration were checked by using the equipment manual; those that needed continuous calibration, the duration was added in the form. In total, 15 forms were filled in. Special calibration stickers were used for each equipment to indicate the date and duration of the calibration.

2.1.4. Work Progress Forms

Three types of Work Progress forms were used by QA Unit personnel, see Table 1. The follow-up of the performed work at each of the six activities in the field, laboratories and office work by the QA Unit personnel was done using the three forms. In total, 1558, 349 and 378 forms were filled in for field, office and laboratory work, see Table 1. Figure 1 is an example of the Field Work Visit Form, those of Office and Laboratory forms are slightly different.

2.1.5. Work Completion Form

This form was filled in by the QA Manger (the current author) for each completed work item mentioned in the strategic project depending on the bill of quantities mentioned in the contract. Each form was signed by the Activity Responsible, QA Manger and the Project Manager, and a copy was submitted to the Client. In total 96 forms were filled in, see Table 1.

2.1.6. Verification Form

This form was filled in by the QA Manager during checking the verification of any work (field, office and laboratory). The type of verification and the verifier person; usually the QC of the activity are mentioned in the form, besides mentioning the title and serial number of the work procedure. In total, 67 forms were filled in, see Table 1.

2.1.7. Committee Meeting Form

A special Reviewing Committee was established in the strategic project. The Activity Responsible, QA Manager and the Project Manager with the deputy were the committee members. However, occasionally, some specialists were invited from Headquarters of GEOSURV to join the committee. The date, time, duration, purpose, and members in attendance of the meeting were mentioned in the form Figure 2. The form was filled in by the QA Manager according to the request of the Project Manager or the deputy and/or any the one responsible for the activity. Occasionally, meetings were conducted upon the request of the Client's responsible. In total 31 forms were filled in, see Table 1.

2.1.8. Reviewing Committee Form

All conducted reports were reviewed by the committee; accordingly, the authors of the reviewed report should amend the report by considering the forwarded comments by the committee members. However, when the authors were not in accordance with a comment or more, then the committee members have to decide which opinion is the right. A total of 20 forms were filled in, see Table 1.

2.1. 9. Nonconformance Form

A nonconformance case is when any field, office or laboratory work is performed with deviation from the involved work procedure, also called "Defect" (Hoyle, 2009; Mitra, 2016). One of the main aims of following-up the work progress in the field, office and laboratory by the QA Unit's personnel using the work progress forms and depending on the work procedures, is to discover any Nonconformance, accordingly a Nonconformance Form was used Figure 3. The recognition of a nonconformance case by the QA Unit's personnel before being recognized by the Client's responsible was one of the main aims of implementing the QA Program in the strategic project. The type of nonconformance, date, work responsible and the one responsible for the activity are mentioned in the form Figure 3. Also, the required corrective actions, which are necessary to overcome the nonconformance case and performing the work according to the involved work procedure. Moreover, it is also shown if the Nonconformance was recognized by the Client's responsible or otherwise. In total, 3 forms were filled in, see Table 1.

2.2. Work Procedure

A work procedure was prepared for each performed item in the strategic project. The one responsible for the activity with the collaboration of the activity experienced staff, prepared work procedures which had to be followed by the activity staff members. Moreover, the QA Unit's personnel used the work procedures to follow-up the work progress. Each procedure included: 1) The required specialization and scientific degree of staff who can perform the concerned work, 2) Step by step description how to perform the concerned work, 3) If equipment needed to perform the concerned work, then the details of the equipment are mentioned, and if calibration is needed, then the calibration procedure and duration are mentioned, 4) If certain work needs certain time interval for performance, then the time interval is

mentioned, 5) Scope of the work, 6) Purpose of the work, 7) Definitions and References, 8) Verification of actions, 9) Used standards, and 10) Documentations and Records. All these items were mentioned in each work procedure. All prepared work procedures were reviewed and approved by the Project Manager and the QA Manager. In total, 79 work procedures were prepared within the strategic project, see Table 2.

Field Work Progress Follow-up Form

Accompanied By:								**Time** AM PM		**Form No.**	
Day		**Date**		**Announced** Yes No							
ACTIVITY		**WORK TITLE**						**Work Procedure No.**			
WORK RESPONSIBLE			**Degree**					**Specialization**			
Name:											
DURATION OF WORK		**Days**			**Number of visits**			**Last date of visit**			
From	**To**	**Total**	**Passed**	**Remained**							
EQUIPMENT Name:			**Calibration**								
			Needed		**Calibrated**			**If yes, valid**			
			Yes	**No**	**Yes**	**No**		**Yes**	**No**		
SITE			**No.**	**Regional**		**Local**		**Step**			
Name:											
SPECIFIC CHECKED WORK		**Traverse**		**Point**		**Hand dug well**					
River	**Spring**	**Pit**	**Log**	**No.**		**Type**					
BOREHOLE	**No.**	**Purpose**		**Type**	**Core**	**Non-core**		**No.**			
Depth Total	**From To**	**Casing needed**		**Casing interval**		**Number of samples**					
		Yes	**No**	**From**	**To**						
Remarks of the Work Responsible (if any**)**											
Remarks on Work Progress (By QA Official**)**											
NONCONFORMANCE		**Report No.**				**Date**					
Type											
Responsible		**Name**				**Signature**					
Work											
Activity											
Q.C.											
QA											
Nonconformance		**Accepted**		**Rejected**		**Date**					
Name		**Job Title**				**Signature**					
This form should be filled by the Q. A. official and should be signed by other responsible with their comments											

Figure 1. Field Work Progress and Follow-up Form.

<table>
<tr><td colspan="7">REVIEW COMMITTEE MEETING NOTICE FORM
Project Name</td></tr>
<tr><td>MEETING</td><td>Day</td><td>Date</td><td>Time</td><td>Duration (hours)</td><td>Form filled by</td><td>Form No.</td></tr>
<tr><td colspan="4">Purpose of meeting</td><td colspan="3">CONTENTS of REVIEW | Activity</td></tr>
<tr><td colspan="4">PARTICIPANTS
A- Review Board Members</td><td colspan="3" rowspan="2">A- Title and Revision Number of the Document to be Reviewed</td></tr>
<tr><td colspan="2">Name</td><td colspan="2">Job Title and Responsibility</td></tr>
<tr><td colspan="2">1-
2-
3-
4-</td><td colspan="2"></td><td colspan="3">Actions</td></tr>
<tr><td colspan="4"></td><td colspan="3">Passed</td></tr>
<tr><td colspan="4">B- Project Team Members</td><td colspan="3" rowspan="2">B- Title and Revision Number of the Document to be Reviewed</td></tr>
<tr><td colspan="2">Name</td><td colspan="2">Job Title and Responsibility</td></tr>
<tr><td colspan="2">1-
2-
3-</td><td colspan="2"></td><td colspan="3">Actions</td></tr>
<tr><td colspan="4">C- Other Invited Participants</td><td colspan="3">Passed</td></tr>
<tr><td colspan="2">Name</td><td colspan="2">Job Title and Responsibility</td><td colspan="3" rowspan="2">DISCUSSANT AUTHOR(S) Name and job title
1-
2-
3-</td></tr>
<tr><td colspan="2">1-
2-
3-</td><td colspan="2"></td></tr>
<tr><td colspan="7">REMARKS and COMMENTS</td></tr>
<tr><td colspan="7">This form should be filled by the Q. A. Manager by four copies: 1)Project Manager, 2) Q. A. Unit, 3) Involved Activity, 4) Review Committee</td></tr>
</table>

Figure 2. Committee meeting notice form.

2.3. Quality Control (QC)

Quality Control (QC) is a process by which entities review the quality of all factors involved in production. ISO 9000 defines quality control as "A part of quality management focused on fulfilling quality requirements" (ISO 9000, 2005). The QA and QC are two aspects of quality management. While some quality assurance and quality control activities are

interrelated, the two are defined differently. Typically, QA activities and responsibilities cover virtually all of the quality system in one fashion or another, while QC is a subset of the QA activities.

ACTIVITY					**Date**	**No.**
NONCONFORMANCE	Designated in Work Procedure No.		Work Progress Form No.		Date	
Work Responsible Name	Specialization				Degree	
TYPE OF NONCONFORMANCE	Personnel position		Type of equipment		Calibration of equipment	
Non-application of Work Procedure	Non following of Work Procedure		Non following of time schedule		Non calibrated equipment	
DESCRIPTION OF NONCONFORMANCE (Written by QA personnel)						
A- Actual condition						
B- Requirements						
NONCONFORMANCE	Accept	Reject	Rework	Conditional	Signature	Date
Work Responsible						
Activity Responsible						
Q C Name						
Q A Official Name						
Q A Manager Name						
Project Manger						
FINAL DECISION						
Explanation (In case of conditional and/ or Rejection)						
Q. A. VERIFICATION	**Required** (List below actions and results)				**Not required**	
ACTION			**Date**	**Accepted**		**If not, write a detailed report**
Performed	Yes	No		Yes	No	
NONCONFORMANCE Designated by the officials of the Client				Yes	No	Date
Name and position of the Client's official with his remarks						
FINAL RESULT						
This form is filled by	**Name**		**Signature**		**Date**	
This form should be filled by the QA Official. A copy is to be submitted to the Project Manager and a second copy to the Activity Responsible. All names should be clearly indicated with their signatures						

Figure 3. Nonconformance Report Form.

Table 2. Statistical data of the strategic project.

No.	Activity Name	Number of Staff	Number of QA visits	Number of Work Procedures
1	**Project Management**	2	-	-
2	**Geology**	21	388	10
3	**Geophysics**	24	308	6
4	**Hydrogeology**	20	287	7
5	**Eng. Geology**	9	297	12
6	**Drilling**	26	308	4
7	**Laboratories**	33	303	39
8	**QA**	2	2	1
Total		**137**	**1893**	**79**

Elements in the quality system might not be specifically covered by QA/QC activities and responsibilities but may involve QA and QC (ISO 9000, 2015). It is worth to mention that without the presence of QC the QA personnel wouldn't be able to follow-up the work progress and verify the performed works in the strategic project.

3. Results

The results of QA Program implementation in the strategic project are mentioned below with emphasis on the main results that are mentioned hereinafter.

3.1. Establishing the QA Unit

Before starting the performance of the strategic project, the QA Unit was established to perform the QA Program in the strategic project that involves geological investigation. The QA Manager (the current author) prepared all requirements to implement the QA Program, the following were performed:

- Indoctrination of the QA perspectives to all staff members of the strategic project, each activity alone.
- Preparations of all forms in the implementation of the QA Program during the performance of the strategic project which included geological investigations.
- Reviewing and approving all used work procedures in the strategic project.
- Following-up all performed works in the strategic project to assure that all work was performed according to the approved work procedures.
- Checking the qualifications of the staff members to be as mentioned in the involved work procedures.
- Checking the calibration of the equipment and that equipment is calibrated as required and mentioned in the work procedures.

3.2. Qualifications of the Staff Members

Before starting the performance of the strategic project, the qualifications of all staff members were documented by the QA Manager using a special form. The documented data of each staff member was approved by the the one responsible for the activity and then by the Project Manager. The number of different degree holders of staff members of each activity, besides the Project Management and QA Unit are presented in Table 3. The total number of staff members was 137. Moreover, the experience and job title of each staff member of the strategic project is presented in Table 4. This documentation was performed to assure that all performed work in the project was carried out by qualified persons.

Table 3. Distribution of different degree holders within the staff members of the strategic project.

No.	Activity Name	Number of Degree Holders				
		Ph.D.	M.Sc.	B.Sc.	Dip.	Others
1	**Project Management**	1	1	-	-	-
2	**Geology**	1	6	14	-	-
3	**Geophysics**	-	5	16	2	1
4	**Hydrogeology**	4	3	9	4	-
5	**Eng. Geology**	1	2	4	2	-
6	**Drilling**	-	-	5	5	16
7	**Laboratories**	2	3	17	9	2
8	**QA**	-	1	1		

Total	**9**	**21**	**66**	**22**	**19**
Grand Total	**137**				
Percentage from Grand total	**6.5 %**	**15.1 %**	**48.9 %**	**15.8 %**	**13.7 %**

Table 4. Experience and Job titles of staff members working on the strategic project.

No.	Activity Name	Occupation				
		Chief (> 15 years)	**Senior (12 – 15 years)**	**Basic (7 – 11 years)**	**Assistant (< 7 years)**	**Others**
1	**Project Management**	2	-	-	-	-
2	**Geology**	4	7	4	6	-
3	**Geophysics**	4	2	14	4	-
4	**Hydrogeology**	3	1	9	3	4
5	**Eng. Geology**	1	1	4	3	-
6	**Drilling**	-	1	3	1	21
7	**Laboratories**	6	4	9	3	11
8	**QA**	1	-	1	-	-
Total		**21**	**16**	**44**	**20**	**36**
Grand total		**101**				
Percentage from Grand total		**20.79 %**	**15.84 %**	**43.56 %**	**19.80 %**	

It is clear from the data presented in Table 3 that among the staff members there are 9, 21, 66, 22 and 19 persons with Ph.D., M.Sc., B.Sc., Dip. and Others, respectively. Whereas from the presented data in Table 4, it is clear that among the experience and job titles of the staff members of the project there are 21, 16, 44, 20 and 36 persons with experiences of more than 15 years, 12 – 15 years, 7 – 11 years, less than 7 years and other, respectively. These data also confirm that the project was performed by well experienced staff, as a requirement of the QA Program. It is worth mentioning that those who were not qualified to collaborate in the project were included in training sessions, and those who couldn't pass the training were not allowed to collaborate on the project. In total, 53 staff members were included in training sessions and 6 of them didn't pass Table 1. This is another confirmation that the project was performed under strict QA requirements.

3.3. Work Progress Follow-up by QA Personnel

All executed work in the strategic project including field, office and laboratory work were followed- up by QA personnel. The daily follow-up of the executed work was documented by using special visit forms. An example of field work visit form is given in Figure 1. Total number of used forms in all activities and for all performed work was 1893 forms, seeTable 2. The QA personnel were using work procedures to follow-up the performed work and to confirm that each work was performed as mentioned in the involved work procedure. In total, 79 work procedures were prepared by the six activities and the QA Unit, see Table 2.

3.4. Nonconformance

One of the main aims for implementing the QA Program in geological investigations is to follow-up the work progress by the QA personnel to assure that all executed work is performed following certain work procedures. However, when any deviation occurs in any performed work then a nonconformance case is registered. A nonconformance case is when any field, office or laboratory work is performed with deviation from the involved work procedure, also called "Defect" (Hoyle, 2009; Mitra, 2016).

In the carried out strategic project, the QA Personnel recognized three nonconformance cases Table 1. One of those cases was recognized by the Client's representative too because the representative was escorting the QA Manager in the project. The nonconformance was in the percentage of the extracted core which was 2% less than that mentioned in the contract (90%).

4. Discussion

This case study dealt with the role of QA implementation in a strategic project that included geological investigations. The strategic project was performed by GEOSURV and the QA Program was implemented by a QA Unit established especially for this purpose. The personnel of the QA Unit have implemented all requirements based on QAM (1987), ISO 9000 (2005 and 2015). The QA Program was implemented successfully during the performance of the strategic project and all outputs were submitted to the Client and were approved and accepted by the representatives of the

Client. The main aims of implementation, the QA Program were to assure that all performed work (field, office and laboratory) were performed according to the approved work procedures, and not to record any nonconformance. However, three nonconformances were recorded in three activities, Hydrogeology, Drilling and Laboratories Table 1. For the recorded nonconformance case in the Hydrogeology Activity was during performance of a pumping test. The calculations of hydrogeological parameters were done before the pumped water was clear. The case was recognized by the QA Manager after less than one hour; accordingly, the pumping test was repeated and calculations of the hydrogeological parameters were calculated after the pumped water was clear. For the second recorded nonconformance case that was recorded in the Laboratories Activity was in the qualification of a personnel who was checking the chemical composition of a sample. According to the involved work procedure, the work should be performed by a B.Sc. holder Chemist; however, the work was performed by a Diploma holder Lab. Assistant. After discussing the case with the QC responsible and the one responsible for the activity, it was found that the person was very well qualified with 25 years of experience in the particular work. Therefore, the nonconformance was accepted as conditional and approved that the quality of the performed work was according to the required specifications. The last nonconformance case was recorded in the Drilling Activity in drilling a borehole with total depth of 200 m, by full core drilling method. This case was recognized by the representative of the Client because he was escorting the QA Manager. The extracted core from the depth 190 – 193 m has 88% which was 2% less than that mentioned in the involved work procedure. According to the signed contract between the Client and GEOSURV (the Contractor), the borehole should be re-drilled. However, the QA Manager succeeded in convincing the Client's representative to check the extracted core from a depth 180 m until 193 m and then to drill another 3 m from depth of 193 – 196 m to check if the extracted core had the same lithology as the extracted core from 190 – 193 m with 88% core recovery. Accordingly, the drilling was continued and the extracted core from 193 – 196 m was the same as that drilled from 180 m, which meant it had the same lithology and the lost 2% of the core would not effect on the acquired data. The case was accepted by the Client and the drilling of the borehole to the deigned depth 200 m was done successfully and paid to GEOSURV.

It is important to mention that the strategic project was performed by the best personnel of GEOSURV with excellent experience, and those who couldn't pass the training courses were not allowed to work on the project Tables 2, 3 and 4. The staff members that worked on the project included geologists, hydrogeologists, geophysicists, engineers, chemists Table 5. This is another reason that the project was carried out with very high performance quality, as confirmed by the Client (Sissakian, 1991). Moreover, GEOSURV; as a contractor among other 6 contractors working with the same Client at different work sites had gained the first quality prize.

Table 5. Number of involved specifications of staff members working on the strategic project.

Geologist	Hydrogeologist	Geophysicist	Engineer	Chemist	Others
35	16	24	6	12	36

5. Conclusions

Implementation of a QA Program in geological investigations within a strategic project that was carried out by GEOSURV has shown that it had a vital effect on the quality of the performed work of the project during 1988 – 1991 in the central part of Iraq. For the first time, a QA program was implemented in GEOSURV very successfully. The performed work by the personnel (2 persons) of the QA Units was one of the main reasons that the performance of the project was successful. The work carried out included filling in: 137 Experience forms, 1893 forms of work progress follow-up divided as 1558 visits to field work, 349 visits to asses office work, and 373 visits to assess laboratory work, 15 calibration forms, 53 training forms, among them 6 didn't pass the training and accordingly were not allowed to join the project, 96 work completion forms, 67 work verification forms and 3 nonconformance forms. The bulk of the work carried out was by two people of the QA Unit and is a clear indication of the successful role of implementation of QA Programs in geological investigations.

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