A FRAMEWORK FOR ESTABLISHING APPROPRIATE TRENCHLESS TECHNOLOGY GUIDELINES AND STANDARDS IN SOUTHERN AFRICA

A Mc N Goyns • FS Crofts

WRC Report No. KV 133/01

Water Research Commission

A FRAMEWORK FOR ESTABLISHING APPROPRIATE TRENCHLESS TECHNOLOGY GUIDELINES AND STANDARDS IN SOUTHERN AFRICA

A contribution to the effective and efficient design, specification, installation, operation, maintenance, and rehabilitation of freshwater supply, wastewater disposal, and other buried services

A Mc N Goyns & FS Crofts

Report to the Water Research Commission by a joint venture between Technikon Pretoria and Pipeline Installation and Professional Engineering Services CC

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EXECUTIVE SUMMARY

The supply of clean water and disposal of wastewater are essential components of primary health care for any community. These services are traditionally supplied via buried pipelines. Trenchless Technology (TT) is the science of installing, repairing or renewing underground pipes, ducts and cables using techniques that minimise or eliminate the need for excavations.

Many of the first generation water supply lines and sewers in South Africa's cities and towns are reaching, or have reached, the end of their design lives and now need to be replaced or rehabilitated. Due to increasing urbanisation and population densities, traditional open-cut or trenching techniques for doing this are becoming more technically difficult, socially disruptive, environmentally unacceptable, and expensive. The option and potential for using TT to install and rehabilitate water and other services is, therefore, becoming increasingly prominent.

Although the trenchless industry has an annual turnover of about R 50-million, hardly any national standards or guidelines exist to set quality requirements for these activities.

The aim of this study was to develop a framework to establish a comprehensive set of national TT standards and guidelines. Phases of the project subsequent to this study will entail the planning and production of these standards.

Output from this document encompasses a framework for:

- guidelines to select, design, and specify TT activities
- standards for pipes, materials and services used in TT installations
- standard specifications for TT installations.

The objectives of this consultancy were achieved by:

(i) undertaking a literature survey that established what TT standards were available both locally and internationally, as well as other sources of information

(ii) corresponding with the International Society for TT and certain of its affiliates, which established that some assistance and guidance could be obtained from these organisations

(iii) conducting interviews with users and suppliers of TT in South Africa, which established the status of the local industry and its market, with particular emphasis on the techniques used and views on standards

(iv) arranging discussions with those involved in the production of SABS construction standards (1200 series), which established that TT construction standards could be produced following the structure and procedures already in place; product and other standards could be

produced using a similar structure and procedure; and more thought would have to be given to the handling of design guidelines

(v) developing a framework, incorporating the range of TT activities currently available in South Africa and providing a structure to produce the required standards.

From these investigations, the following conclusions are drawn:

- The necessary information is available to produce TT standards, but this would have to be adapted to South African conditions.
- No effort appeared to have been made internationally to compile a set of standards of the nature envisaged by this project.
- All categories of TT methods and activities were used in South Africa, and there was overwhelming support for the production of national TT standards.
- Analysis of the interviews provided a new perspective on the TT industry and its composition in South Africa.
- Inadequate attention appeared to be paid to the design of TT installations. This could result in:
  - Conservative over-specification and unnecessary expenditure
  - Risky under-specification and unexpected failure
- Structures and procedures were available to produce standard specifications for TT installations and standards for products, materials and services, but there was uncertainty about handling design standards.
- The framework would provide an effective means of ensuring the logical development of TT standards.

Recommendations are made which are specific to this study and to the subsequent investigations, which will address the researching, planning and production of the required TT Standards. These are:

- Distribute this report to various parties involved with producing national standards.
- Use the framework developed to motivate the need to develop TT standards and guidelines.
- The Southern African Society for Trenchless Technology should produce a directory of TT services based on the framework.
- Undertake research and development aimed at transferring and adapting international technology to South African conditions.
- Engage in capacity building and skills/technology transfer for this developing industry.
- Implement a plan for producing the required TT Standards.

ACKNOWLEDGEMENTS

This report is the result of a study aimed at developing a framework for establishing appropriate trenchless technology guidelines and standards in southern Africa.

The study was made possible by the financial support from the Water Research Commission (WRC), for which acknowledgement and thanks are due.

The steering committee members responsible for the study were:

- Mr F Crofts* : Civil Engineering Department, Technikon Pretoria
- Mr A Geertsema : Civil Engineering Department, Technikon Pretoria
- Mr A Goyns* : Pipeline Installation and Professional Engineering Services (PIPES) cc
- Mr P le Roux : Keeve Steyn Consulting Engineers
- Mr J van Wamelen : Boutek, CSIR
- Mr J Wessels : Tshwane City Council.

The contribution of each of these members is acknowledged with thanks.

*Members highlighted by means of an asterisk were members of the working group that conducted the investigations and produced this report.

A special word of thanks are due to Mrs G Goyns for the typing, layout and editing of the report and to Mr R Corin for doing the final review.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BS	British Standard
CCTV	Close Circuit Television
CEN	Comité European de Normalisatione
EN	European Norm
GPR	Ground Penetrating Radar
GRP	Glass-reinforced plastic pipe
GSTT	German Society for Trenchless Technology
HDPE	High density polyethylene
ID	Internal diameter
INDSTT	Indian Society for Trenchless Technology
ISTT	International Society for Trenchless Technology
ISO	International Standards Organisation
NASTT	North American Society for Trenchless Technology
ND	Nominal diameter
PVC	Polyvinyl chloride
SA	South Africa
SABS	South African Bureau of Standards
SAICE	South African Institution of Civil Engineering
SASTT	Southern African Society for Trenchless Technology
SSTT	Scandinavian Society for Trenchless Technology
TC	Technical Committee
TT	Trenchless Technology
WRC	Water Research Commission
UK	United Kingdom
UKSTT	United Kingdom Society for Trenchless Technology

1. INTRODUCTION

1.1 Background

Constitutionally, the entire population has a right to clean water and a healthy environment. However, only 50% of SA's population have basic services. Moreover, demands in urbanized areas for housing and visible services, such as roads and power supply, often take precedence over the hidden services such as water supply and wastewater disposal. Of major concern is that many of the first generation water supply pipelines and sewers in SA's cities and towns are reaching or have reached the end of their design lives and now need replacement or rehabilitation.

Trenchless Technology (TT) is the science of installing, repairing or renewing underground pipes, ducts and cables using techniques that minimise or eliminate the need for excavations. [3, pA2] TT systems fall into three broad categories, namely:

- installation of new services using techniques such as pipe jacking, micro-tunnelling and directional drilling
- on-line replacement of existing services using techniques such as pipe-bursting and pipe-splitting
- renovation of existing services using techniques such as sliplining and cured-in-place lining.

Prior to the selection and use of these techniques, three essential services are needed, namely:

- site investigations to determine soil and groundwater conditions
- pipeline or service inspections to assess conditions
- location surveys to locate pipelines, other services and potential obstacles.

Brief descriptions of the various techniques are given in the Glossary of Terms (pp 51 –59).

TT is possibly the most significant single development in utility construction since man decided to change from open sewers running along city streets to conduits buried below the surface. Apart from eliminating the odours, this concept made a sigificant contribution towards the eliminnation of diseases such as cholera, that periodically ravaged European cities during the 19th century and provided more space on the streets. The buried conduit concept was also adopted when other services were introduced with the modernisation of the cities. There is now a maze of services below the streets of any modern city, making access to them extremely difficult.

Due to increasing urbanization and population density in southern Africa, competition for space below the city streets is equivalent to that of any other modern city. Hence, the installation of new services, and rehabilitation and upgrading of existing services using traditional open-cut techniques will become:

- technically more difficult
- socially more disruptive

- environmentally more unacceptable
- more expensive

as there will be less space available for digging trenches. Thus the demand for TT is likely to increase as it has done elsewhere in the world where similar problems have occurred.

Internationally, the older European, American and Japanese cities have had to address the problem of aging sewers and pipelines. Due to space contraints, social pressures, environmental considerations, and economics, TT solutions were developed for:

- installing new
- on-line replacement of old
- renovation and repair of existing

water and other buried services. Internationally, TT has been a growth industry for at least two decades. Many of these techniques could be adapted to southern African conditions. Due to the rate of urbanisation and the uncontrolled way in which this sometimes occurs in the developing nations, problems with the installation and rehabilitation of services may, in fact, be exacerbated.

Probably the greatest obstacles to the use of TT in southern Africa are:

- little understanding of the management of buried services during their lifecycle
- little understanding or awareness of the capabilities and benefits of TTapplied to this
- no national standards to provide guidelines for selecting, designing and specifying TT work.

The compilation of TT standards, in particular guidelines, and later a code of practice, and an associated awareness campaign to promote their use would help to overcome these obstacles and encourage the use of TT in southern Africa, with significant and widespread benefits.

With these standards, the client and designer will have a consistent means of comparing various TT solutions and choosing the best one for a particular project.

1.2 Aims and Objectives of Study

The overall aim of this study is to develop the framework for establishing an appropriate set of SA national standards for the complete range of Trenchless Technology (TT) activities, ie:

- Guidelines and Code of Practice for Selecting, Designing, and Specifying TT Work
- Standards for Pipes, Materials and Services used in TT Work
- Standard Specifications for TT Installations.

The objectives set to meet the overall aim of this study were to establish:

(i) what national and international TT standards are available and what other sources of information can be accessed to assist with the production of TT standards

(ii) the status of TT in South Africa with respect to:

(a) awareness of the technology

(b) frequency and reasons for using it

(c) range of activities

(d) who makes the technical decisions

(e) what technical decisions are made and the products and specifications used

(f) views of users and providers about standards

(iii) how the production of TT standards could be facilitated by using the structures and procedures already established in South Africa

(iv) what TT standards are currently required in South Africa.

1.3 Methodology

To meet the objectives, the following tasks were carried out:

- preparatory work and project planning
- literature survey [objective (i)]
- discussion document [objective (i)]
- correspondence with ISTT and affiliates [objective (i)]
- questionnaires [objective (ii)]
- select interviews with potential users [objective (ii)]
- select interviews with TT industry [objective (ii)]
- contact with other organizations [objective (iii)]
- identification of standards needed [objective (iv)].

The preparatory work and methods used to carry out each task are described, where necessary, in the relevant sections of the report. The information from the above tasks is combined to establish the framework within which TT standards can be produced. The extent to which the overall aim and individual objectives of this consultancy have been met are discussed and conclusions are drawn. This report concludes with recommendations about how to produce TT standards within the framework developed in this consultancy.

2. LITERATURE AND INFORMATION SURVEY

Information was gathered from several sources, namely:

- International Society for Trenchless Technology (ISTT)
- American Society for Testing and Materials (ASTM)
- South African Bureau of Standards (SABS)
- a web search
- other sources.

The literature survey was undertaken by Technikon Pretoria as part of this study. Although this covered the first three sources of information, it also focused on the electronic media. The full literature review report is in Appendix A. A synthesis of this follows.

2.1 ISTT Publications

ISTT was formed in September 1986. There are now 25 affiliated organizations, representing various countries worldwide. These societies focus on the urban environment and serving those involved with the provision of underground utilities. Their specific objectives are to:

- advance the science and practice of TT for the benefit of the public
- promote education, training, study and research in the science and practice of TT [1, p3].

ISTT publishes:

- a monthly magazine, *No-Dig International*, which features articles on new developments and applications, together with news items and information on technical, financial and legal aspects of TT worldwide
- a Year Book [5] with full listings of corporate and individual members, and details of all affiliated societies.

The organisation has also produced:

- a TT database in the form of a multi-media CD [1, p17]
- Introduction to TT [2]
- TT Guidelines in booklet form [3]
- A glossary of trenchless terms (included in this report) [3, pp N1-N8].

The publication *Trenchless Technology Guidelines* covers the whole range of TT services and techniques, but makes the comment: "No attempt has been made to include detailed specifications and codes of practice since these vary from place to place, and information on these matters should be sought from local Societies or member companies." [3, A1]

Since 1987, ISTT has, in conjunction with affiliates, organised 18 International NO-DIG Conferences and Exhibitions, the full proceedings of which have been published. Many of the papers presented are at the cutting edge of TT. However, despite mention of standards and quality, there are few papers on this topic.

The paper by Etzink and Gumbel [6] is an exception, describing the standardisation of plastic piping systems for renovation being undertaken as an initiative by the International Standards Organisation (ISO) through its Technical Committee TC138. This paper includes a framework for renovation system standards [4, pE2-10] and a classification of rehabilitation options [4, pp E2-2, E2-3], which has been included in the glossary of terms given in this report.

2.2 ASTM Publications

ASTM has bound all its standards relating to TT into a single document [5]. However, of the 78 standards, only 11 cover actual TT activities, and there is no explanation of how these standards should be linked into a package or module when dealing with a particular application, as envisaged in this study.

2.3 SABS Library

Relevant details are:

- There are 105 SABS Standards relating to pipes or piping. Of these, 33 could have relevance to TT, but only three relate directly to TT (pipe jacking).
- The ISO, TC138 standards, which cover plastic piping and fittings, are available at this library. There are 111 of these available at this library.
- Comité Européan de Normalisation (CEN) TC155 has 54 standards for plastic piping and fittings.

These documents would have to be scanned to ascertain which are relevant to TT and what amendments are needed to ensure that they meet the requirements of trenchless installations.

2.4 Web Search

The web search revealed a wealth of information on TT. The following is of direct relevance:

> *Standards and specifications on pipe materials and the installation thereof are generally covered by ASTM standards, but there are also proprietary construction specifications. ASTM standards cover the whole spectrum of pipes, namely concrete, vitrified clay, fibreglass pipe, steel pipe, ductile iron pipe, glass reinforced concrete, PVC, polyethylene and various rehabilitation systems. These have been collected in a single publication [5]. No evidence of a similar comprehensive set of specifications and standards in the UK or Europe was found.* [6, p8]
>
> *The Societies on TT in the various countries cover most aspects of specifications in this field in association with other bodies and learned societies on an ad hoc basis.* [6, p7]
>
> *A number of tender specifications and tender documents are readily available from various trenchless sewer specialists through the Directional Crossing Contractors Association at a small cost* [7, p7]
>
> *International TT research colloquiums where researchers from all over the world are present facilitate debate on topics considered to be of the most importance to the delegates. This information is also accessible on a web page* [1, p7]

The ASTM publication mentioned here is the same as that discussed under 2.3 above [5].

From the web search, it is evident that a wealth of information is available on TT. However, there is little information on standards per se and no evidence could be found indicating that any overseas country had produced TT standards in a similar format to that of SABS 1200 or that envisaged by this study. [6, p8]

2.5 Other Sources

Other sources of information identified are:

- Rand Water library have a selection of the Water Research Centre (UK) and American Water Works Association publications.
- Several of the interviewees who have international connections and information.
- Standards and specifications for both TT Installation and Materials used are well-established in Japan and Germany.
- Discussion documents produced by the chairman of Technical Committee (TC5120.61) for Construction Standards [8 and 9]
- A selection of texts on buried pipes and the proceedings from several No-Dig Conferences.

3. INVESTIGATION

To establish what international TT standards are available and what other sources of information can be accessed, letters were written to ISTT and several of the affiliated organisations.

To establish the status of TT in South Africa, telephonic and face-to-face interviews were conducted with two groups to cover the full spectrum of those involved in the TT industry, namely:

- users and potential users of TT (marketplace interviews)
- SASTT members.

Contact was also made with the SABS and the chairman of the Technical Committee responsible for the SABS 1200 series for construction works.

In addition to this, telephonic contact was made with several government departments that could possibly benefit from the application of TT in an endeavour to establish who the key technical decision-makers were in these departments.

3.1 Methodology

Based on the information available, a discussion document was prepared to serve as the basis of letters and interviews. This included a diagram showing the relationship between the various "Trenchless Technology Activities" used when designing the questionnaires and when developing the "framework for TT standards", which constituted the aim of this study. This discussion document is attached as Appendix B1.

Two questionnaires were designed to provide the information needed to meet the requirements of objectives and their various elements concerning the status of TT in South Africa.

Although almost identical, the one questionnaire focuses on the users and potential users of TT (marketplace) and the other on the suppliers of TT (SASTT members). They are structured so that the data can be presented quantitatively. These are reproduced in Appendices B2 and B3.

The questionnaires consisted of 18 multiple-choice questions and two questions asking for comment. These, in turn, were categorised into six sections, namely:

- interviewee classification
- awareness with regard to TT
- use of TT
- trenchless techniques/services used or offered
- design and specification of trenchless installations
- TT standards.

It was planned to conduct ±20 interviews in each category. For the marketplace, the following procedure was planned:

- Establish key decision-makers in the sewer and roads sections of major municipalities, in utility organisations, and large consulting engineering firms in Gauteng.
- Make telephonic contact with these decision-makers and arrange interviews.
- Conduct interviews at which the purpose of the project was explained (based on discussion document) and the questionnaire answered.
- Combine all the responses so that they could be presented both statistically and graphically.
- Evaluate the responses and give quantitative comment on which conclusions could be drawn or recommendations made.

For the interviews with SASTT members, the following procedure was planned:

- Make telephonic contact with each individual member and the official representative of each corporate member to arrange interviews.
- Repeat the last three steps listed above for the marketplace interviews.

Several of the SASTT members who held senior positions at local authorities or consultants were requested to complete the marketplace questionnaire rather than the one for SASTT members.

3.2 Correspondence with ISTT and Affiliates

Letters based on the Discussion Document and requesting information were written to the Chairmen/Secretaries of:

ISTT : International Society for Trenchless Technology

ASTT : Australasian Society for Trenchless Technology
GSTT : German Society for Trenchless Technology
INDSTT : Indian Society for Trenchless Technology
NASTT : North American Society for Trenchless Technology
SSTT : Scandinavian Society for Trenchless Technology
UKSTT : United Kingdom Society for Trenchless Technology
and to Dr J Gumbel, Chairman, European Committee on Rehabilitation.

Responses were received from:
Mr J Castle of ISTT
Dr J Gumbel
Mr I Vickridge of UKSTT
Mr R Bielecki of GSTT.
All of the above respondents indicated that they would correspond further on the topic.

From these replies and the publications, the following points were relevant:

- Germany, Japan and USA have done the most in the field of TT standards (Mr J Castle)
- GSTT Consulting are in a position to write the standards (Mr R Bielecki)
- ASTM has compiled a document on standards related to TT (Mr I Vickridge)
- UKSTT is discussing the issue of TT Standards and Specifications (Mr I Vickridge)
- The Trenchless Technology database on CD has sections dealing with the selection of techniques for water, sewerage, gas and cable utilities [1 p 17]
- The emerging CEN product standards for plastic liner pipes, as well as other published European pipeline rehabilitation standards classified by application area (sewers, water, gas) would be a good starting point for writing standards in South Africa (Dr J Gumble).
- There are not yet any unified international design specifications, but there are efforts to reconcile and update different national approaches in Europe and North America (Dr J Gumble).
- Many ISO standards are being incorporated into the European Committee for Standardization as European Norm Standards (EN) (Dr J Gumble).

3.3 Marketplace Interviews

A list of 20 organisations in Gauteng was compiled and key decision-makers identified. However, there were several factors that had an impact on the number of interviews and manner in which they were conducted, ie:

- The current re-organisation processes being undertaken by local authorities made it difficult to contact the targeted persons.
- Once contacted, several of the targeted persons gave referrals to others.

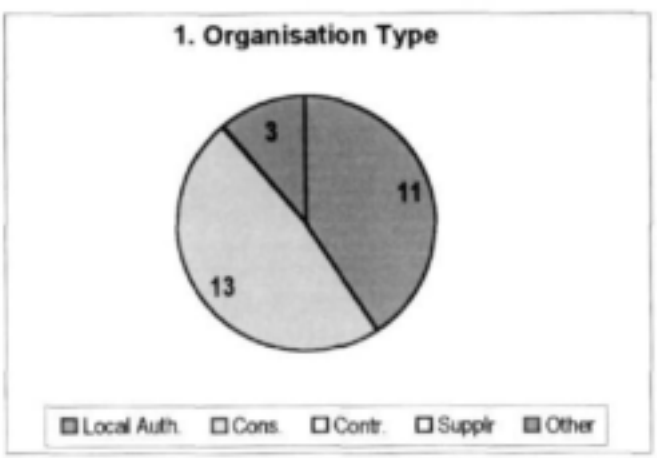
- Several of the person-to-person interviews were with more than one person, and included recommendations to make further contacts.
- Many contacted telephonically asked that the questionnaires be e-mailed or faxed to them.

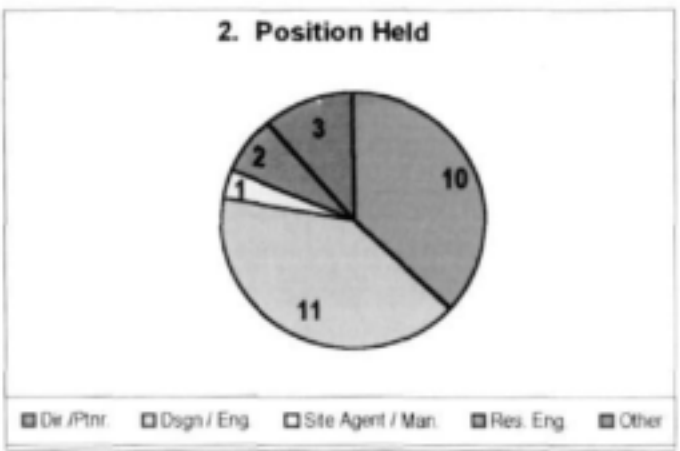
In response to the above, it was decided to follow the telephonic contact with an e-mail or facsimile of the questionnaire rather than a person-to-person interview. As a result, 34 interviews were conducted with representatives of 26 organisations. There were 27 replies to the 34 questionnaires sent out, giving a 79% response rate. Appendix B4 gives details of these interviewees.

The numerical results of these interviews are recorded in Appendix B2. Charts have been compiled using this information and are reproduced below. For most questions, the total number of responses exceeds 27 because more than one alternative was applicable. As answers are given by representatives from different types of organisation, there are some techniques, such as reaming (Question 8), that consultants or clients have used but are not currently available in South Africa.

Ranking of answers is given in Table 1 overleaf. This is followed by a graphic presentation of the responses to each of the multiple chose questions, plus details of any data adjustments and significant facts. These charts have been based on this ranking and adjustment of the values given in Appendix B2. Where relevant, discussion of these results and the conclusions drawn from them are given in Section 5.2.1 of this report.

3.3.1 Interviewee Classification



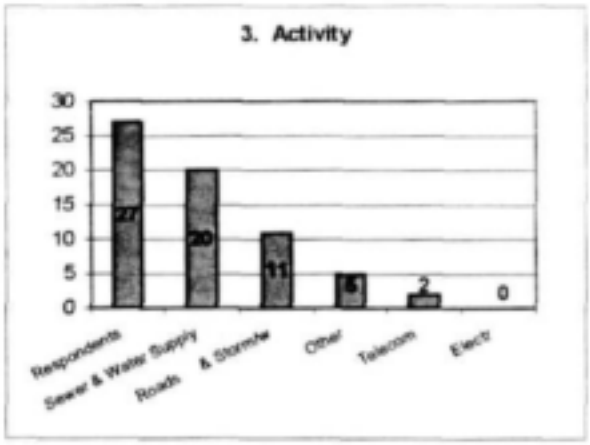


Organisation type (Question 1) : The respondents were almost equally split between client organisations (utilities and local authorities) and consultants.

TABLE 1 : Quantification of answers to market questionnaires

Question	Alternative	Numbers	Percentages
I. Interviewee Classification			
1. Organisation type	Consultant; local authority; other	13; 11; 3	48; 41; 11
2. Position held	Partner/director; designer/engineer; other	16; 7; 1	59;37;4
3. Activity	Sewer & water; roads & stormwater; other; Telkom; electricity	20; 11; 5; 2; 0	74; 41; 19; 7; 0
II. Awareness of TT			
4. Know about	TT; SASTT; No-Dig International; ISTT; SASTT member	27; 15; 11; 10; 6	100; 59; 41; 37; 22
III. Use of TT			
5. Frequency	Sometimes; seldom; when possible; never; when applicable	12; 8; 5; 1; 1	44; 29; 19; 4; 4
6. Reasons	Economic; social; environmental; other	17; 15; 14; 8	63; 56; 52; 30
IV. Trenchless techniques used			
7. New construction	Pipe jacking; directional drilling; auger-boring; ramming; moling; micro-tunnelling	22; 13; 3; 3; 3; 1	81; 48; 11; 11; 11; 4
8. On-line replacement	Pipe-bursting/splitting; reaming; eating	11; 2; 0	41; 7; 0
9. Renovation (lining)	Slip; cured-in-place; spray; preformed	10; 7; 6; 1	37; 26; 22; 4
10. Repair	In situ; localised; restore bedding support; rerounding	9; 8; 2; 1	33; 30; 7; 4
11. Inspection & locating services	CCTV; cleaning; leak detection; GPR; sonar	20; 12; 11; 4; 0	74; 44; 41; 15;0
12. Other services			
V. Design of trenchless installations			
13. Done by	Specialist; self; contractor; others; not done	14; 13; 8; 2; 0	52; 48; 30; 7; 0
14. Details specified	Nominal ID; class; strength; minimum ID; pressure; other	15; 15; 12; 7; 5; 5	56; 56; 44; 26; 19, 19
15. Products specified	Concrete; polyethylene; steel; PVC; clay; GRP	20; 15; 5; 4; 1; 1	74; 56; 19; 15; 4; 4
16. Product specifications used	SABS; own; project specific	10; 3; 2	37; 11; 7
VI. Trenchless technology standards			
17. Standards used	Project specific; national; own; other; none	19; 15; 9; 2; 1	70; 56; 33; 7; 4
18. Organisations views	Would use if available; would comment; support use; would contribute technically; would contribute financially	26; 18; 15; 12; 6	96; 67; 56; 44; 22
19. Views about national standards	Would comment; further information required; would contribute technically	18; 17; 11	67; 63; 41
20. Additional comment made by respondents (See text)			

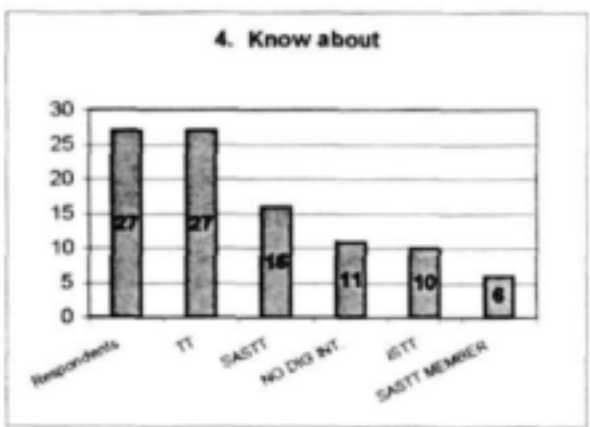
Position held (Question 2) : For purposes of classifying decision-making levels, those who indicated two positions were allocated the higher position. In addition, departmental heads, chief engineers and associates were grouped together with directors and partners. All the respondents were either in senior management or technical positions.



Activity (Question 3) : The respondents' main fields of activity were sewers and water supply, and roads and stormwater. There was limited success in identifying respondents in the other fields of activity.

3.3.2 Awareness of TT

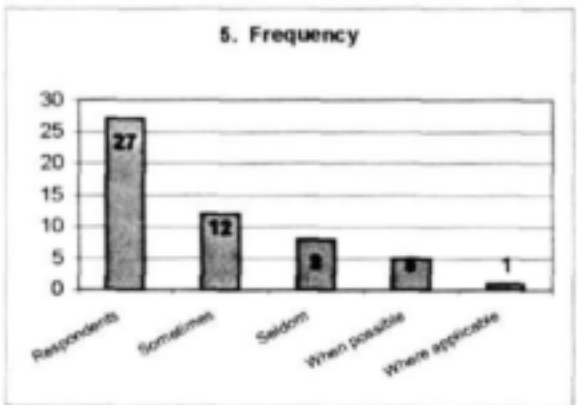
Awareness about TT (Question 4) : All the respondents knew about TT, but less than 60% knew about SASTT and only 22% were SASTT members.

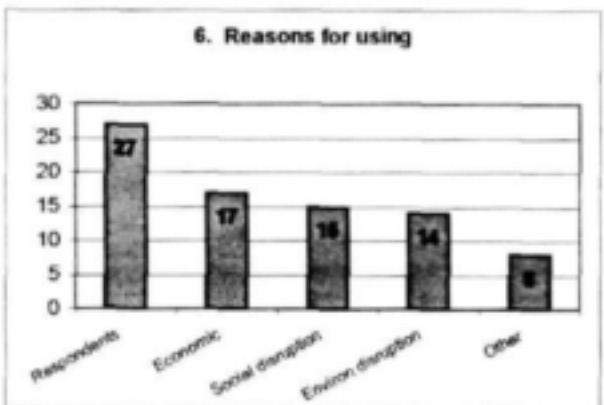


3.3.3 Use of TT

Frequency of use (Question 5) : Of the respondents, 44% sometimes, 29% seldom and 19% used TT whenever possible.

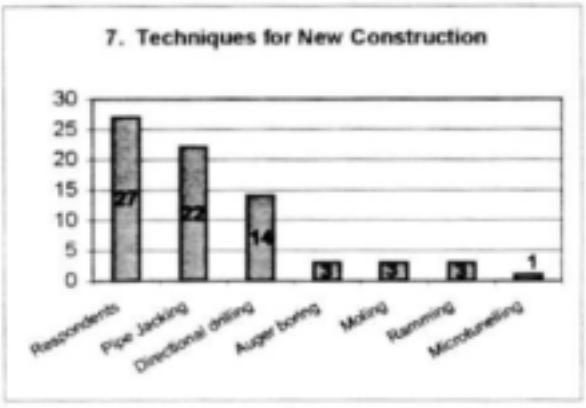
Reasons for using (Question 6) : *The dominant reasons for using or not using TT were economic* (63%), social (56%), and environmental (52%) factors. Other reasons for using or not using TT were given by 30% of the respondents.

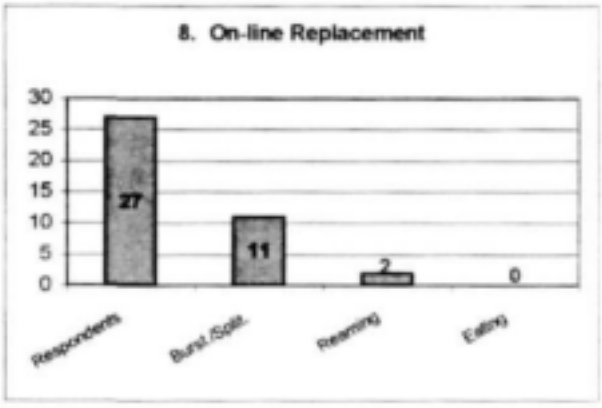




3.3.4 Trenchless Techniques/Services Used

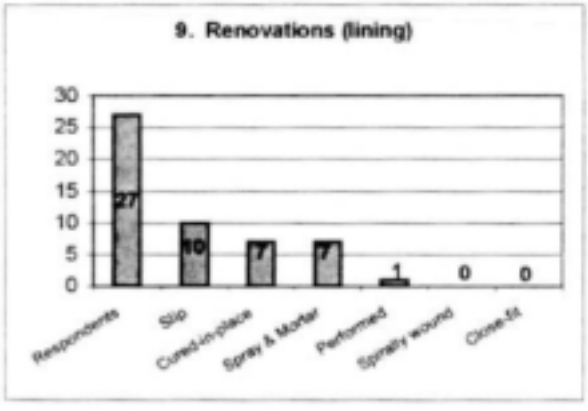
Almost all (26: 96%) of the respondents had been involved in TT in one way or another. Most of this involvement had been in new construction (25; 93%), or inspection and location (20; 74%). There were only eight (30%) who had been involved with all five categories. The others had had minimal involvement; several had used only one technique.

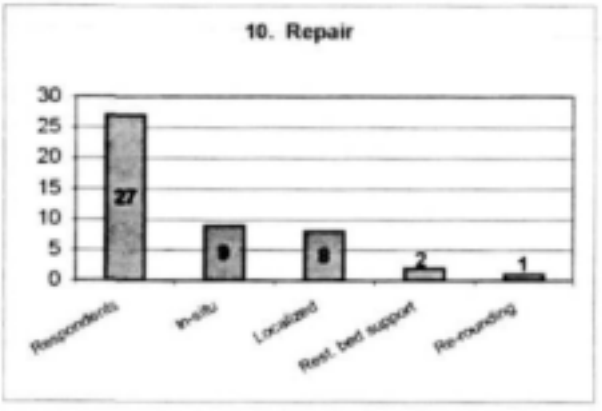




TT used for new construction (Question 7) : Almost all the respondents (25; 93%) had been involved with TT in new construction. The responses to guided boring and directional drilling are combined (See discussion in Section 5.2.1).

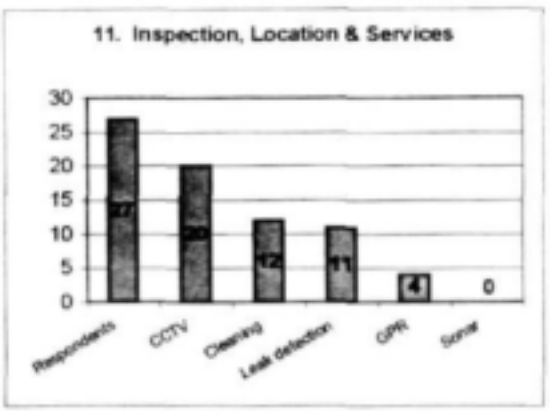
On-line replacement (Question 8) : Of the respondents, only 13 (48%) had been involved in on-line replacements. Pipe bursting and pipe splitting are grouped together as they do the same thing. Pipe reaming and eating are discussed in Section 5.2.1.





Renovation (Question 9) : Of the respondents, 12 (44%) had been involved with renovation. The techniques most frequently used by the respondents were sliplining, cured-in-place lining and mortar lining. Spray and mortar lining have been grouped together.

Repair (Question 10) : Of the respondents, 13 (48%) had been involved with repairs. The commonly used were in situ and localized. Other techniques had been used by two of the respondents.

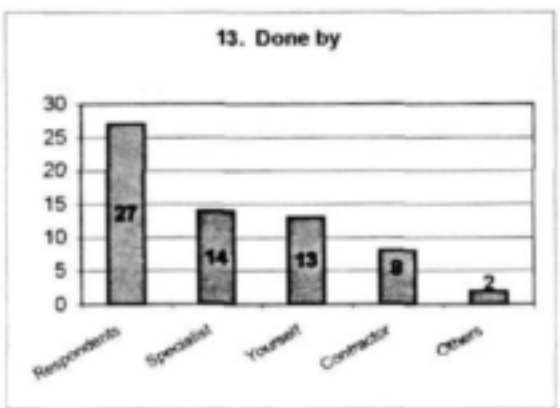


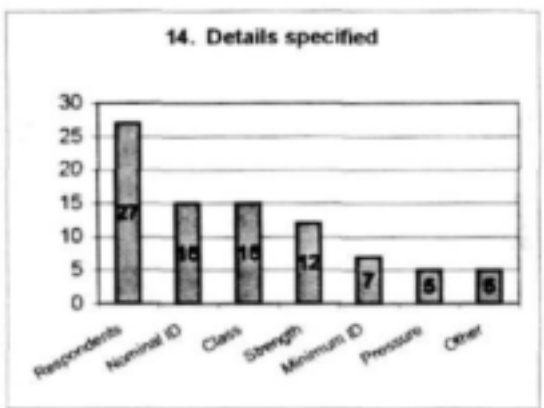
Inspection and Location of Services (Question 11) : Ground penetrating radar (GPR) and other techniques for locating buried services are grouped together.

The most frequently used techniques were CCTV (20; 74%), cleaning (12; 44%), leak detection (11; 41%) and service location four (15%).

Other Techniques (Question 12) : One other technique that was used was joint sealing using a silica-based activator.

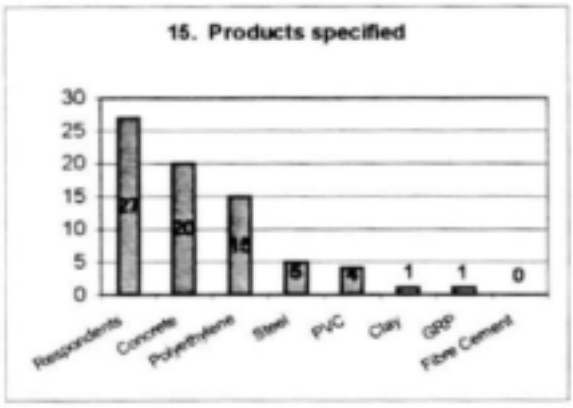
3.3.5 Design of Trenchless Installations

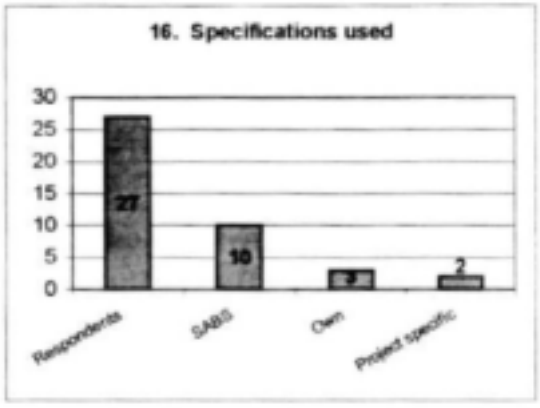




Design of Trenchless Installations (Question 13) : Most of the design work was done by the client, the consultant or a specialist (21; 78%) and several of these (4: 15%) also involved the contractor in the design. In certain cases, the design was left to the contractor (4; 15%) and two of the respondents said no design was done at all.

Details Specified (Question 14) : Of the respondents, 15 (56%) specified nominal diameter (ND) and class of pipes needed, 12 (44%) the strength and seven (26%) the minimum internal diameter (ID). Several respondents 6 (22%) also specified the pressure required.



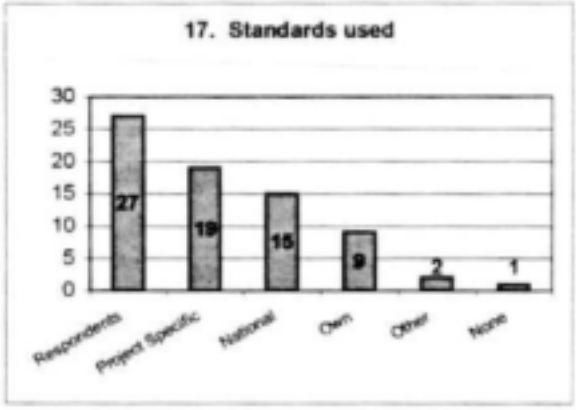


Products Specified (Question 15) : Of the respondents, 20 (74%) specified concrete, 15 (56%) HDPE and five (19%) steel.

Product Specifications Used (Question 16) : Of the respondents, 10 (37%) used SABS product specifications. Of these, seven (26%) used the concrete pipe specification and three (11%) the HDPE pipe specification.

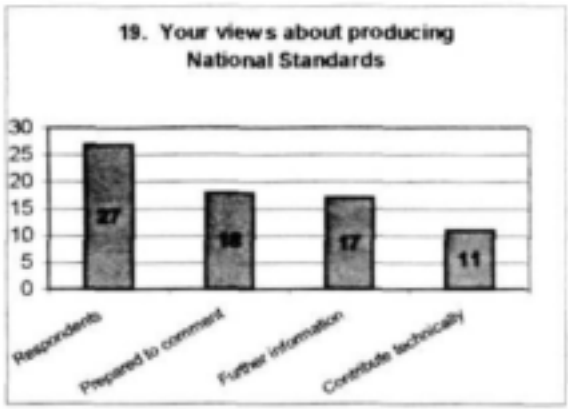
3.3.6 Trenchless Technology Standards

Standards Used (Question 17) : The majority of respondents indicated that they used project standards (19; 70%) and/or national standards (15; 56%). Another 9 (33%) used their own standards or their own in conjunction with national or project specific standards.



Organisations' Views on Standards (Question 18) : All 27 respondents indicated that they would use national standards if they were available, 18 (67%) indicated they were prepared to comment, 15 (56%) would support the writing thereof, 12 (44%) would contribute technically, and 8 (30%) would consider contributing financially. This clearly indicated market support for the writing of TT standards.

Views About Project (Question 19) : Of the respondents, 18 (67%) indicated that they were prepared to comment on and 11 (41%) that they would be prepared to contribute technically. In addition, 17 (63%) indicated that they would like further information on this project.



Question 20 : Additional Comment

The majority 20 (74%) of the respondents added comment to their questionnaires. (See discussion in Section 5.2.1 and Appendix B8.

3.4 SASTT Member Interviews

It was originally intended to conduct 20 interviews with SASTT members. However, following the comments from the interviewees in the marketplace about electronic distribution, it was decided to distribute the questionnaires to all SASTT members.

Of the 25 corporate members, 23 were sent questionnaires. (The international member was not contacted and one of the corporate local authority members was interviewed as a marketplace representative.) Of the 19 individual members, 12 were sent questionnaires. (The others were either sent marketplace questionnaires or were directly involved with the project.)

The procedure followed was to e-mail all these members with a copy of the SASTT Member Questionnaire. In total, 35 members were contacted. However, there were multiple responses from some of the organisations. As a result, there were potentially 40 questionnaires that could have been answered. There were 34 replies to these, giving an 85% response rate. Appendices B5 and B6 give details of these interviewees.

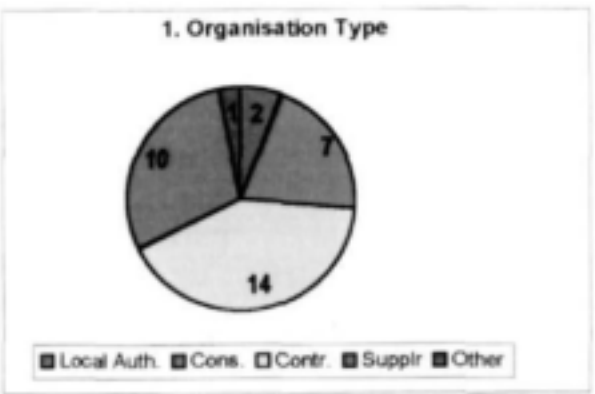
The numerical results of these interviews are recorded in Appendix B3. A series of charts was compiled using this information and are reproduced below. For most questions, the total number of responses exceeds 34 because more than one alternative was applicable. There are some techniques that the TT contractors can offer due to their overseas connections, but are not currently used in South Africa, such as rerounding (Question 10). However, these facts have been included in the responses. Adjustments and significant facts that can be drawn from these questionnaires are detailed below. Ranking of the answers is given in Table 2 overleaf.

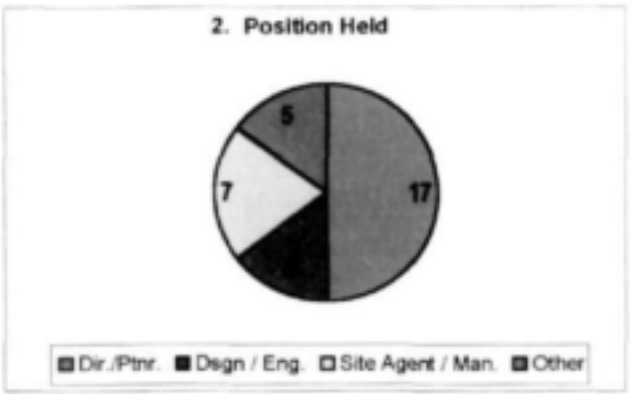
This is followed by a graphic presentation of the responses to each of the multiple-choice questions plus any necessary data adjustments and significant facts. Where relevant, a discussion of these results and the conclusions that can be drawn from them is given in Section 5.2.2 of this report.

TABLE 2 : Quantification of answers to SASTT member questionnaires

Question	Alternative	Numbers	Percentages
I. Interviewee Classification (34 respondents)			
1. Organisation type	Contractor, supplier, consultant, local authority, other	13; 11; 7; 2; 1	41; 29; 21; 6; 3
2. Position held	Partner/director; site agent; design engineer; other	17; 7; 5; 5	50; 21; 15; 15
3. Activity	New construction; renov; insp & locat; on-line repl; suppliers; repair	19; 14; 11; 10; 10; 9	56; 41; 32; 29; 29; 26
II. Awareness of TT (34 respondents)			
4. Knowledge of TT	High; medium; low; no comment	14; 10; 6;4	41; 29; 18; 12
III. Use of TT (34 respondents)			
5. Specification by	Self; consultant; client; contractor	24; 18; 14; 3	71; 53; 41; 9
6. Reasons	Social; environment; economic; other	26; 22; 18; 4	76; 65; 53; 12
IV. Trenchless techniques used (14 respondents)			
7. New construction	Pipe jacking; directional drilling; moling; auger boring; ramming; micro-tunnelling	6; 6; 4; 4; 3; 3	43; 43; 29; 29; 21; 21
8. On-line replacement	Pipe bursting/splitting/cracking	5	36
9. Renovation (lining)	Slip; preformed; close-fit; cured-in-place; spray/mortar; spirally wound	8; 4; 4; 3; 2; 1	57; 29; 29; 21; 14; 7
10. Repair	In situ; localised; restore bedding support; rerounding	6; 2; 1; 1	43; 14; 7; 7
11. Inspection & location	CCTV; cleaning; GPR; leak detection; cable & pipe detection	7; 5; 3; 0; 0	50; 36; 21; 0; 0
12. Other techniques	Offered by contractors (See text)		
V. Design of trenchless installations (34 respondents)			
13. Done by	Self; specialist; others; contractor	22; 10; 7; 5	65; 29; 21; 15
14. Details specified	Minimum ID; class; strength; nominal ID; pressure; other	20; 18; 16; 15; 14; 5	59; 53; 47; 44; 41; 15
15. Products specified	Concrete; polyethylene; steel; clay; PVC; GRP; fibre cement	18; 17; 11; 8; 7; 6; 2	53; 50; 32; 24; 21; 18; 6
16. Product specifications used	Other; SABS; own; ISO	4; 4; 2; 1	12; 12; 6; 3
VI. Trenchless technology standards (34 respondents)			
17. Recommended	National; project specific; own; other; none	24; 18; 12; 4; 1	71; 53; 35; 12; 1
18. Organisations views	Use if available; would comment; contribute technically; support; contribute financially	29; 25; 15; 10; 3	85; 74; 44; 29; 9
19. Views about national standards	Further info; will comment; extra comment; will contribute technically	19; 19; 14; 13	56; 56; 41; 38
20. Additional comment	Made by respondents (See text)		

3.4.1 Interviewee Classification

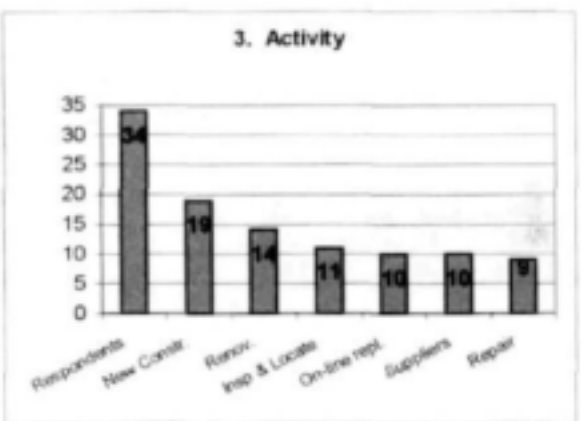




Organisation Type (Question 1) : The respondents were split between trenchless contractors, material or equipment suppliers, consultants, local authorities, and other in just about the same proportion as the SASTT membership (14; 10; 7; 2; 1).

Position Held (Question 2) :

Half the respondents were either directors or partners in their organisations. The remaining were in managerial (7; 21%), design or engineering positions (5; 15%), or a range of other positions.

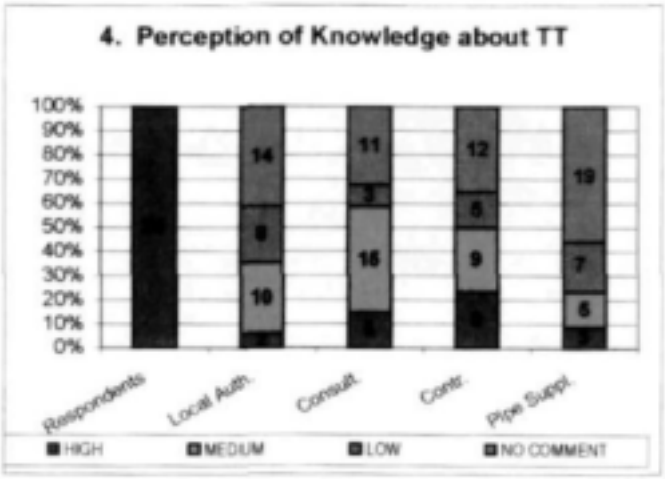


Activity (Question 3) : Respondents covered all aspects of TT activity, the activities with which they were most frequently involved being new construction (19; 56%) and renovation (14; 41%). Almost equal numbers were involved in the other activities.

3.4.2 Awareness of TT

The bars on this chart show the respondents' perceptions concerning knowledge of TT in both the demand and supply segments of the TT industry.

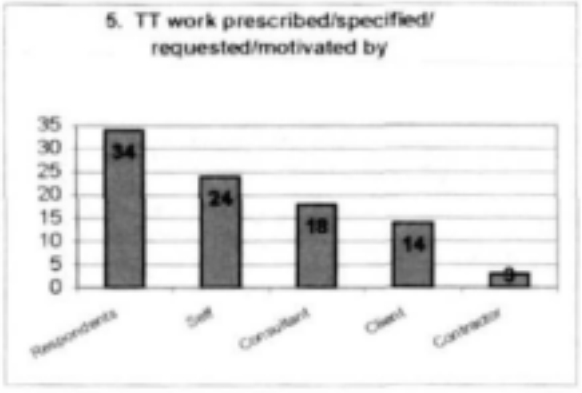
Perception of Knowledge about TT (Question 4) : A global evaluation of the answers, obtained by averaging the scores for the four categories of respondents, is given in Table 2. This shows that 14 (41%) of the averaged respondents either had no opinion or did not wish to comment. Less than a third (29%) were of the opinion that there was a moderate awareness of TT, and only 13% were of the opinion that there was a high awareness of TT.

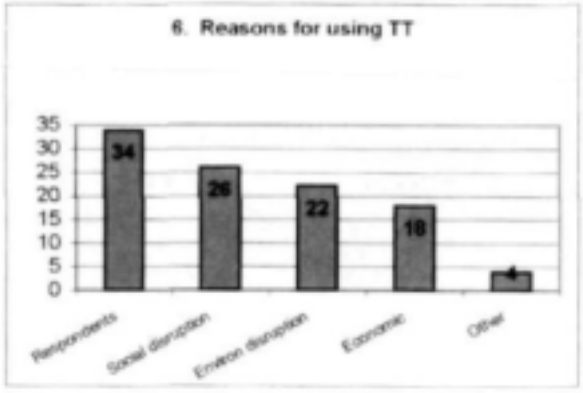


3.4.3 Use of TT

Prescription/specification/request/motivation for TT work (Question 5) : Of the respondents, 24 (71%) stated that TT work was motivated by themselves, 18 (53%) specified by the consultants and 14 (41%) prescribed by the client.

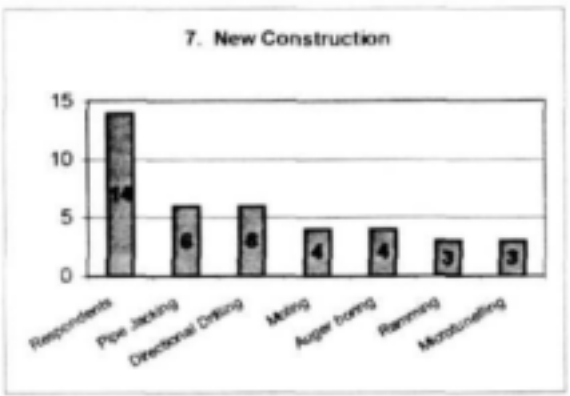
Reasons for using TT (Question 6) : The reasons given by respondents for using TT were social (26; 76%), environmental (22; 65%) and economic (18; 53%).

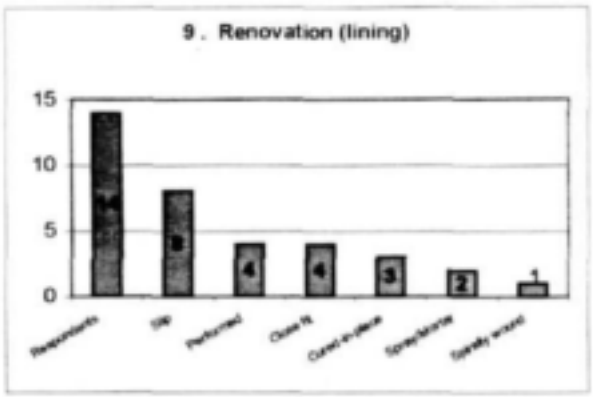




3.4.4 Trenchless techniques/services offered

The responses to this set of questions are limited to those from the 14 contractors who participated in the investigation.



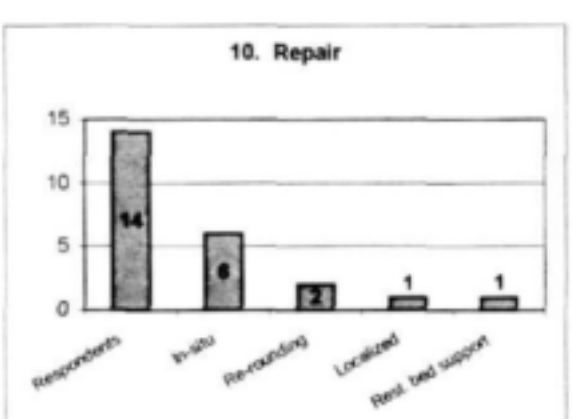


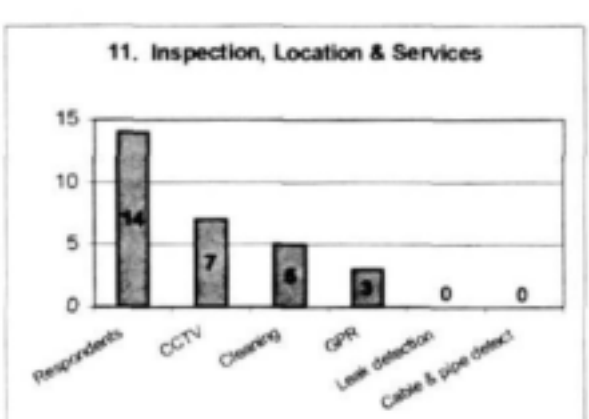
New construction (Question 7) : Of the 14 contractors who responded, nine (64%) offered TT for new installations. Of these, six (43%) offered jacking, and six (43%) directional drilling. The other techniques were offered by a smaller number of members.

On-line replacement (Question 8) : The pipe bursting/cracking/splitting technique was offered by five of the respondents. No other techniques were offered.

Renovations (linings) (Question 9) : *The most frequently used is sliplining (8; 57%). Four of the* contractors that responded offered both close-fit liners and preformed liner elements, two mortar-lining, and one spirally-wound liners.

Repair (Question 10) : *Six (43%) of the contractors did repair work and all of these offered in situ* repair services. Two of the contractors included re-rounding in their services, one the restoration of bedding support, and one localized repairs.

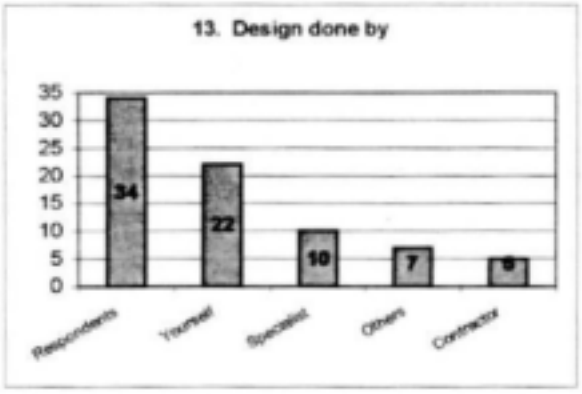


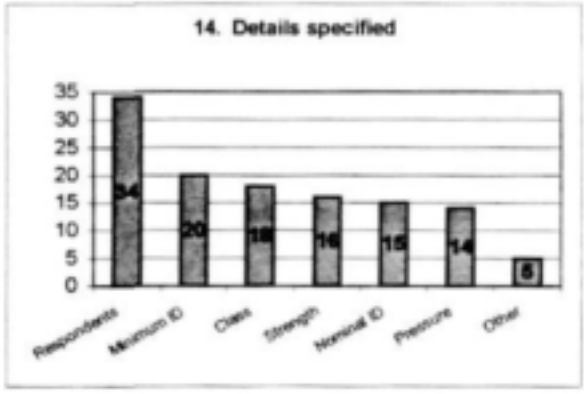


Inspection and location (Question 11) : GPR and radar are essentially the same and are grouped together. Seven (50%) of the contractors did the inspection and location of services. All of them used CCTV. Other services offered by the contractors were pipe-cleaning (5) and GPR (3).

Other techniques used (Question 12) : There were several other services/techniques that the respondents offered, namely technical assessment, tunnelling (new construction), swage lining (renovation), and cable and pipe detection (inspection and location).

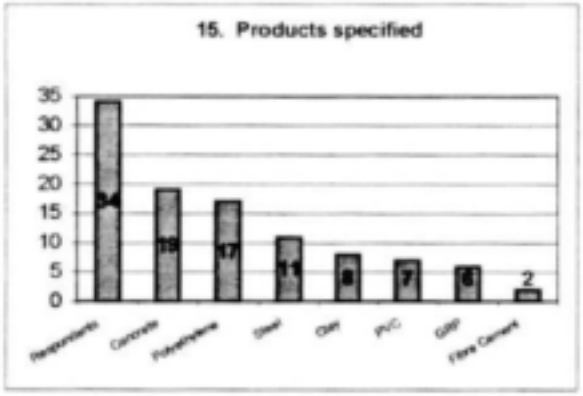
3.4.5 Design of Trenchless Installations

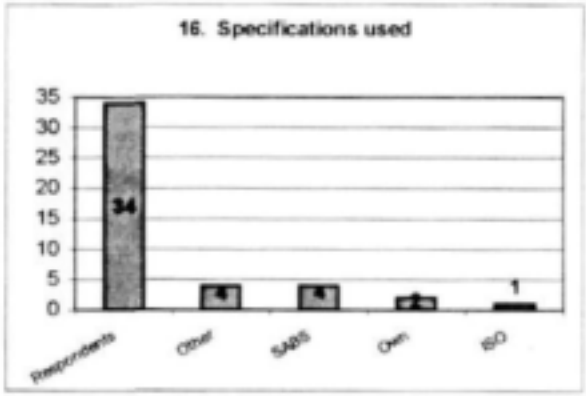




Design done by (Question 13) : The majority (22; 65%) of respondents, irrespective of the organisation type, indicated that design was done by themselves; or by themselves in conjunction with others. Details of these are 13 of the 14 contractors (93%), six of the seven consultants (86%), two of the 10 suppliers, and one of the two local authorities.

Details specified (Question 14) : Most of the respondents (25; 74%) specified either the minimum or nominal ID of the pipe and 21 (62%) specified either strength or class. The most commonly specified single details were minimum internal diameter (20; 59%) and class (18;53%). Actual strength and nominal diameter were specified by 16 (47%) and 15 (44%) respectively. Pipe pressure requirements were specified by 14 (41%).



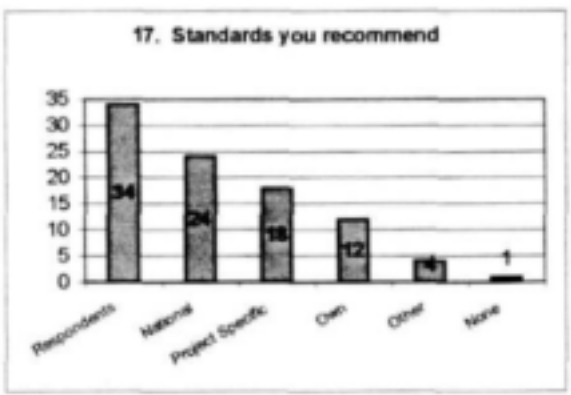


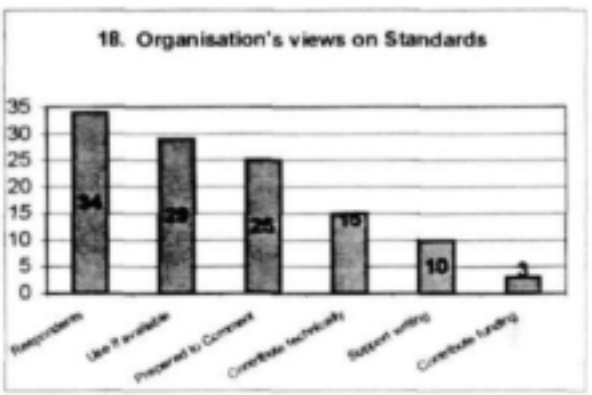
Products specified (Question 15) : The two products most commonly specified by the respondents are concrete (19; 56%) and HDPE (17; 50%) used for pipe jacking and sliplining or

pipe-pulling respectively. Other materials specified are steel (11; 32%) for pipe ramming, clay (8; 24%), PVC (7; 21%) GRP (6; 18%) and fibre-cement (2; 6%).

Installation specifications used (Question 16) : The single specification most commonly used by respondents is SABS 1200 LG for pipe jacking (4; 12%). The respondents used other specifications more frequently than SABS. In certain cases, consultants wrote their own or used project specifications (3; 9%).

3.4.6 Trenchless Technology Standards



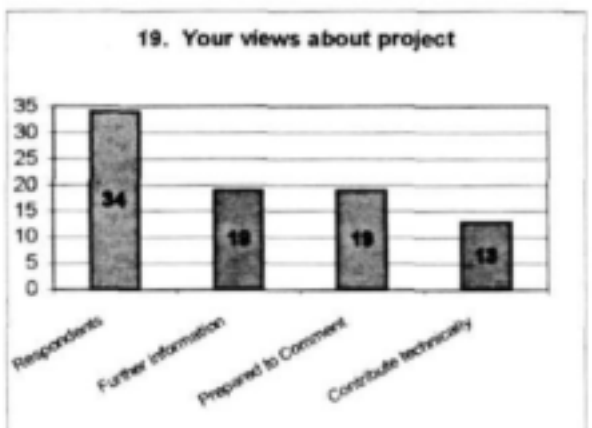


Standards you recommend (Question 17) : Of the respondents, 24 (71%) recommended the use of national standards, 18 (53%) project specific standards, and 12 (35%) their own standards.

Organisation's views on standards (Question 18) : Most (29; 85%) of the respondents indicated that they would use these standards if they were available. A large proportion (25; 74%) indicated that they would be prepared to give comment on the standards and 15 (44%) and 10 (29%) indicated that they would contribute technically towards the standards and support the writing respectively. Three (9%) and another possible two (6%) indicated that they would consider funding the production of such standards.

Respondents' views about project (Question 19) :

Nineteen (56%) of the respondents indicated that they would like to be kept informed about the project. Nineteen (56%) were prepared to comment on the standards in their own capacity, and 13 (38%) were prepared to contribute technically.



Additional comment (Question 20) : Of the respondents, 14 (41%) added comment to their questionnaires. A full listing of these, with organisation names omitted, is given in Appendix B10. The most significant of these have been condensed and combined into the following:

- Consultants and clients should be encouraged to use competent contractors and the available standards (for jacking pipe).
- There is an interest from the marketplace for the production of TT standards.
- There are too many unqualified contractors trying to do TT work. The award of contracts should be based on the competence and track-record of the contractor and not price alone.
- TT standards should be produced as soon as possible.
- Standards should include installation procedures, product specifications, and the bills of quantity for all types of TT work.
- There should be guidelines for doing basic calculations, so that the economic benefits of TT can be presented at the planning stages of a project.
- Priorities are:
  - Revise the concrete pipe specification to include requirements for jacking pipe.
  - Provide better soils information.
  - Specifying what was required of CCTV surveys.
- There were several offers of help with the production of standards and, in particular, the use of international standards, which were available for most of the construction procedures.

3.5 Contact with Other Organisations

As all potential user organisations ultimately fall under the jurisdiction of one or other government department, contact was made with each relevant department to establish the correct contact person with whom TT standards should be discussed. The purpose of doing this was to find contact persons so that "awareness creating" information could be distributed in the future. The following departments were contacted:

- Environmental Affairs and Tourism
- Health
- Housing
- Public Works
- Water Affairs and Forestry
- The National Roads Agency
- Spoornet.

The latter two were contacted in lieu of the Department of Transport, as contacts in these organisations were already known and responses to the marketplace questionnaires were obtained.

Contacts were established for the Departments of Public Works and Water Affairs and Forestry. Other persons contacted were:

- The chairman of the SABS Technical Committee TC5120.61 for the SABS 1200 series (Standard specifications for civil engineering construction)
- The project co-ordinator of Mechanical, Automotive and Civil Standards at the SABS
- The Director of the South African Institution of Civil Engineering (SAICE).

The purpose of these contacts was to establish how these key persons saw the TT standards would be linked to, or fitted into the SABS 1200 series.

They all agreed in principle that:

- Standard specifications for TT construction should fit into the SABS 1200 series.
- Product/material standards would need to be treated separately from the SABS 1200 series.

There were SABS standards for the pipes used in trenchless installations. However, in general, they did not include the necessary clauses or tests to ensure that they were adequate for trenchless as distinct from open cut installations. The necessary changes to these documents could be effected via the set procedures for amending SABS standards [9].

Although there was acceptance of the need for a design standard, there were no definite views about how this should be approached. In discussion with the above key people and others, possible ways of addressing this were raised, including:

- Produce separate design guidelines for each type of installation under the auspices of SASTT
- Produce a national code of practice for the design of TT installations
- Incorporate the design of TT installations as an additional part to SABS 0102 The Selection of Pipes for Buried Pipelines
- Incorporate the design of TT installations as additional sections to the proposed four parts of SABS 0102.

Two additional factors of significance were that SABS had an agreement with ISO whereby the latter's standards could be reproduced by SABS, or used as the basis of new SABS standards and that members of an official SABS working group could obtain SABS and ISO standards relevant to their project free of charge.

A suggestion was made that a particular TT activity be chosen and that a pilot project be conducted on this, including draft documents on:

- design guidelines
- an amended product standard
- a construction standard specification.

4. FRAMEWORK FOR TT STANDARDS

Ideas from several sources, namely the framework for renovation systems standards [4, pp E2-10]; the ISTT Buyers Guide [7]; documents provided by the Chairman of TC5120.61 [8 & 9]; and the diagram developed for the discussion document (Appendix B1, p5) have been combined to produce a framework covering the range of TT activities that are and could potentially be used in South Africa.

4.1 Structure of Framework

The framework given in Figure 1 overleaf is the key output of this study. It was based on ordering the major elements into four levels in the same sequence as that in which decisions about providing a service would be done, namely:

- service provided (Level 1)
- trenchless activity (Level 2)
- standard type (Level 3)
- system standards (Level 4).

The purpose of Levels 1, 2 and 3 of this framework is to introduce a logical structure into which the system standards of Level 4 can fit. Should any new TT activities be introduced to South Africa, they can be fitted into this framework and the relevant system standards added.

For each type of service provided (Level 1), there are a large number of TT activities (Level 2) that could be applicable. These activities fall into several categories, depending on whether the service to be installed is new; an old service requiring rehabilitation in the form of on-line replacement, renovation, repair, or only maintenance; or a service that has to be inspected to determine its condition or located so that other services can be installed. Each of the activities, in general, will be covered by three standard types (Level 3), ie a code of practice; a product/material/service standard; and a standardised specification for construction.

These will comprise a system standard (Level 4) for each product/material/service and for each TT activity. The codes of practice will be system standards that cover a range of activities where the same principles apply. Each of the activities would be covered in a separate section of the code. It is envisaged that all these documents will be produced as national standards.

These standards will be grouped together into an "activity module" which will be a stand-alone set of documents dedicated to that particular activity. Each module will consist of the relevant:

- section or sections of a code of practice
- product/material/service standards
- construction standard.

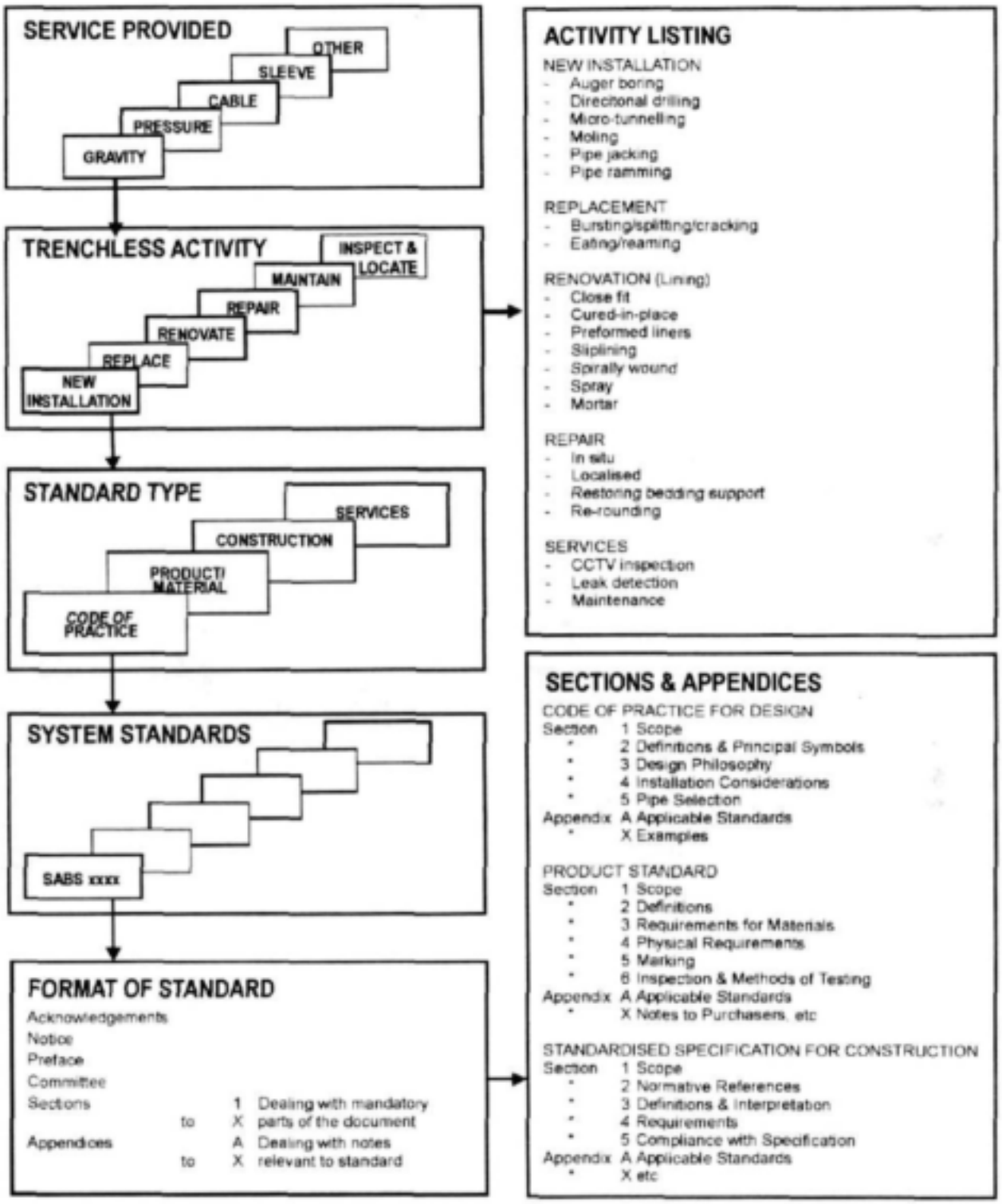


Figure 1 : Framework for TT Standards

The format for SABS documents has been standardised for product/material standards and construction standards [9]. Service standards would follow a similar format, while that of code of practice would depend on its particular scope. Hence, if a particular standard were available from another standards organisation or another source and it suited South African conditions, all that would be necessary to produce it as an SABS standard would be to obtain permission for its use and fit it to the prescribed format.

4.2 TT Standards Needed

The number of TT standards required is evident from the activity listing in Figure 1. The details of this are presented in Table 3 overleaf, from which it can be seen that 23 modules would be required to cover all the TT activities that could be offered in South Africa at present.

For new construction, replacement or renovation, design guidelines, product or material standards, and construction standards are needed (15 modules). For repairs, material standards and construction standards are needed (four modules). For services, only service standards are required (four modules).

4.3 Available TT Standards

There was not even one group of standards currently available in South Africa that could be combined into a module as envisaged in this project.

The literature survey identified few design standards or guidelines, but information is available from representatives of the TT industry to produce those needed, or to amend those available to meet South African conditions. This information is summarised in Table 4.

The design standards could initially be produced as design guidelines and later combined into a code of practice. Certain design guidelines would be applicable to several of the activities, thus reducing the number of design guidelines required to five, namely for:

- Concrete pipes for TT applications
- Clay pipes for TT applications
- HDPE pipes for TT applications
- Steel pipes for TT applications
- Pipeline renovation systems.

When products are installed using TT, they are subject to significant longitudinal forces that would not occur during open-cut installations. Current design practice assumes that any longitudinal forces are handled by the flexibility provided at pipe joints. However, for TT installations, this is not adequate due to pushing or pulling the pipes into place and the fact that many installations use

"jointless" pipes. Design guidelines must include the necessary clauses to cover both loads during construction and installed conditions.

TABLE 3 : TT Activity Modules and System Standards Required

Activity	Module	Design	Pipe	Material	Service	Cnstrctn
NEW CONSTRUCTION	1.0					
Auger boring	1.1	Yes	Yes			Yes
Directional drilling	1.2	Yes	Yes			Yes
Micro-tunnelling	1.3	Yes	Yes			Yes
Moling	1.4	Yes	Yes			Yes
Pipe jacking	1.5	Yes	Yes			Yes
Pipe ramming	1.6	Yes	Yes			Yes
REPLACEMENT	2.0					
Bursting/splitting/cracking	2.1	Yes	Yes			Yes
Eating/reaming	2.2	Yes	Yes			Yes
RENOVATION (Liners)	3.0					
Close fit	3.1	Yes	Yes			Yes
Cured-in-place	3.2	Yes		Yes		Yes
Preformed liners	3.3	Yes		Yes		Yes
Sliplining	3.4	Yes	Yes			Yes
Spirally wound	3.5	Yes		Yes		Yes
Spray	3.6	Yes		Yes		Yes
Mortar	3.7	Yes		Yes		Yes
REPAIR	4.0					
In situ	4.1			Yes		Yes
Localised	4.2			Yes		Yes
Restoring bedding support	4.3			Yes		Yes
Re-rounding	4.4					Yes
SERVICES	5.0					
CCTV Inspection	5.1				Yes	
Leak detection	5.2				Yes	
Cleaning	5.3				Yes	
Utility location	5.4				Yes	
TOTALS	**23**	**15**	**10**	**8**	**4**	**19**

TABLE 4 : Availability of Design Standards

TT Activity	SABS	Other	Comment
NEW CONSTRUCTION			Details available for writing design guidelines
Auger boring			
Directional drilling			
Micro-tunnelling			
Moling			
Pipe jacking	0102		
Pipe ramming			
REPLACEMENT			Details available for writing design guidelines
Bursting/splitting/cracking			
Eating/reaming			
RENOVATION (Liners)			
Close fit		ASTM F1606/F1584	
Cured-in-place		ASTM F1216	
Preformed liners			
Sliplining		ASTM F585	
Spirally wound		ASTM F1741	
Spray			
Mortar			

Current pipe standards have also been written for products being installed in open trenches and may need additional clauses to ensure that the pipes meet the requirements for the additional longitudinal stresses that would be imposed on them during trenchless installations. One area that will need particular attention is the jointing of pipes, because the additional longitudinal stresses due to pushing or pulling pipes in TT installation could over-stress the joints and result in leakages.

While all pipes currently used in new construction, replacement or renovation are covered by SABS standards, none of the materials used in renovation or repair are covered by SABS standards.

In the case of clay pipe, which is offered for TT work but not yet used, there is both an ASTM Standard and a BS Standard. The other lining systems are covered by international standards.

The SABS standards for pipes that would need to be evaluated and, probably, amended and lining material standards needed are given in Table 5 overleaf.

TABLE 5 : Availability of Product/Lining/Material Standards

Activity	Mod.	Pipe	Lining	Material	SABS	Other	Comment on SABS
NEW CONSTRUCTION	1.0						
Auger boring	1.1	HDPE			533		Needs amendment
Directional drilling	1.2	HDPE			533		Needs amendment
		Concrete			677		Needs amendment
Micro-tunnelling	1.3	Clay				BS EN295-7	In use
						ASTM C1208M	In use
Moling	1.4	HDPE			533		Needs amendment
		Concrete			677		Needs amendment
Pipe jacking	1.5	Clay				BS EN295-7	In use
						ASTM C1208M	In use
Pipe ramming	1.6	Steel			719		Needs amendment
REPLACEMENT	2.0						
Bursting/splitting/cracking	2.1	HDPE			533		Needs amendment
Eating/reaming	2.2	Concrete Clay			677		Needs amendment
RENOVATION (Liners)	3.0						
Close fit	3.1	HDPE			533	ASTM F1504	Needs amendment
Cured-in-place	3.2		Polyester			ASTM D5813	Need standard
	3.3		GRP				
Sliplining	3.4	HDPE			533		Needs amendment
Spirally wound	3.5		PVC			ASTM F1697	Need standard
Spray	3.6			Epoxy			See Table 6
Mortar	3.7			Cement			See Table 6
REPAIR	4.0						
In situ	4.1			Cement-based			See Table 6
Localised	4.2			Various			See Table 6
Restore bedding support	4.3			Various			See Table 6
Re-rounding	4.4						

As the various pipe types are used in more than one application, the number of standards to be amended is reduced to three, namely:

- SABS 533 for HDPE pipe
- SABS 677 for concrete pipe
- SABS 719 for steel pipe.

The pipe or material standards to be produced on the basis of international documentation are:

- vitrified clay pipe for jacking
- cured-in-place linings
- preformed GRP linings
- spirally-wound liners
- epoxy lining
- mortar lining.

The only construction activity covered by an SABS Standard is jacking of concrete pipe (SABS 1200 LG). From comments made during the interviews and on the questionnaires, users of this document are satisfied with it. TT contractors and equipment suppliers have indicated that they would assist with the production of construction standards by providing standards from international contacts. Several of the renovation techniques were covered by ASTM standards [5].

As each of these construction activities is unique, a separate construction standard is needed for each one. This means that a total of 19 construction standards need to be produced:

- *new construction (five)*
- replacement (two)
- renovation (seven).

It would appear that most repairs are either covered by project specific documentation or proprietary systems. The most effective way of handling this is probably to combine the general information available into "Guidelines for Pipeline Repair" and to produce a separate standard for each of the four repair techniques, namely:

- in situ
- localized
- restoring bedding support
- re-rounding.

As these are generally proprietary systems, the material requirements should be included with method of application.

There are no SABS standards covering the provision of TT services. The providers of CCTV inspection, utility location and leak detection services have indicated that they would assist with compiling standards for defect or observation classification and output requirements from their systems. There was no comment about cleaning.

Here, again, the most effective way of handling this is probably to produce "Guidelines for TT Services" and four separate operating standards for:

- CCTV inspection
- leak detection
- utility location
- pipeline cleaning.

Details of TT construction standards and services needed is summarised in Table 6 below.

TABLE 6 : Availability of Construction Standards

TT Activity	Module	SABS	Other	Comment
NEW CONSTRUCTION	1.0			In use and available from contractors & equipment suppliers
Auger boring	1.1			
Directional drilling	1.2			
Micro-tunnelling	1.3			
Moling	1.4			
Pipe jacking	1.5	1200LG		
Pipe ramming	1.6			
REPLACEMENT	2.0			In use and available from contractors & equipment suppliers
Bursting/splitting/cracking	2.1			
Eating/reaming	2.2			New technology
RENOVATION (Liners)	3.0			These would have to be compared with the current need in South Africa
Close fit	3.1		ASTM F1606	
Cured-in-place	3.2		ASTM F1216	
Preformed liners	3.3			
Sliplining	3.4		ASTM F585	
Spirally wound	3.5		ASTM F1741	
Spray	3.6			
Mortar	3.7		AWWA C602	
REPAIR	4.0		Project specific proprietary systems	Produce "Guidelines for pipeline repair"
In situ	4.1			
Localized	4.2			
Restoring bedding support	4.3			
Re-rounding	4.4			
SERVICES	5.0			Produce "Guidelines for TT Services" and operating standards
CCTV Inspection	5.1			
Leak detection	5.2			
Maintenance	5.3			
Utility location	5.4			
Pipeline cleaning	5.5			

4.4 Work Needed on TT Standards

The foregoing indicates that work on 39 TT standards is required. Several other issues need to be addressed in addition to the above, namely:

- guidance on the compilation of a contract document for a trenchless project

- measurement and payment for TT construction
- contractual matters such as conditions of tender, conditions of contract, and contract agreement.

The first issue can be covered by a set of guidelines. The other issues should be dealt with as recommended by the technical committee for the 1200 series [8] so that there is consistency on all construction contracts in the built environment.

Hence there are 40 documents to produce, amend or revise, namely:

- five sets of design guidelines
- three SABS product specifications
- six SABS pipe or lining material standards
- 15 SABS construction standards
- guidelines for pipeline repair
- four SABS repair standards
- guidelines for TT services
- four operating standards for TT services.

Once most of the documents have been produced, the design and other guidelines can be combined into three codes of practice, thus reducing the number of standards required to 32.

4.5 Priorities for Activity Modules

An indication of the priorities for producing "activity modules" was obtained by ranking the use of the activities as given by the responses to both sets of questionnaires. This is detailed in Table 7 overleaf.

From an overall perspective, the most frequently used activities, based on the results of the responses, are:

- pipe jacking (concrete)
- CCTV inspection
- directional drilling
- sliplining
- cleaning
- pipe bursting/splitting
- in situ repair
- cured-in-place linings.

Concrete pipe jacking is the only activity where all the relevant facets are covered by SABS standards. SABS 0102 [10, 29, 30, 64] covers the selection process, SABS 677 [12] the pipe and SABS 1200 LG the installation. However, SABS 677 for concrete pipe makes no reference to the use of

this product for jacking. Hence, changes are required to this specification. Apart from this pipe specification, there are no standards covering the pipes/materials used in the other activities.

TABLE 7 : Ranking of Activity Module Priorities

Activity	Module	Demand	Supply	% Score	Combined
NEW CONSTRUCTION	1.0				
Auger boring	1.1	13	8	20	10
Directional drilling	1.2	3	3	48	3
Micro-tunnelling	1.3	18	12	13	18
Moling	1.4	14	8	20	11
Pipe jacking	1.5	1	3	62	1
Pipe ramming	1.6	15	12	16	16
REPLACEMENT	2.0				
Bursting/splitting/cracking	2.1	5	6	39	6
Eating/reaming	2.2	16	18	4	21
RENOVATION (Liners)	3.0				
Close fit	3.1	21	8	15	17
Cured-in-place	3.2	10	12	24	8
Preformed liners	3.3	19	8	17	15
Sliplining	3.4	7	1	47	4
Spirally wound	3.5	22	18	4	22
Spray	3.6	23			23
Mortar	3.7	11	16	20	12
REPAIR	4.0				
In situ	4.1	8	3	38	7
Localised	4.2	9	18	19	13
Restoring bedding support	4.3	17	18	7	20
Re-rounding	4.4	20	16	11	19
SERVICES	5.0				
CCTV Inspection	5.1	2	2	62	2
Leak detection	5.2	6		21	9
Cleaning	5.3	4	6	40	5
Utility location	5.4	12	12	28	14

Although pipe bursting/splitting appears quite far down in the ranking, the steering committee were of the opinion that this, in combination with CCTV inspection, cleaning and sliplining, would constitute ideal activities for a pilot project, as:

- These were established TT activities that had gained market acceptance and were frequently used in combination.

- There were many problems with old sewers in South Africa, which called for on-line upsizing and replacement (rather than renovation).
- The activity module would cover design guidelines, service standards, a product standard and construction standards, thus providing a model for the production of future modules.
- The information was available to write these standards.

The priorities for producing the other activity modules can be based on the rankings of Table 7, unless there were unforeseen factors that necessitated a change to these.

5. DISCUSSION

The overall aim of this study, ie to develop a framework for establishing an appropriate set of South African national TT standards, was achieved in that:

- The sources of information needed to write most of these standards have been found.
- The full range of TT activities currently used and offered in South Africa has been listed.
- The required format for these standardised documents has been established.
- The standards to cover the current activities have been identified and prioritised.

5.1 Sources of Information

The ISTT publications provided descriptive information on the various trenchless techniques and provided the basis for compiling the activity listing [7] and the glossary of terms [3].

Correspondence with ISTT and affiliated societies provided an international perspective to the subject of standards. This also revealed that there were two significant sources of information on TT standards, namely:

- the ASTM collection of standards on TT [5]
- the European Committee on Rehabilitation (Dr J Gumbel).

The ASTM publication contains several standards that could be used as systems standards, but they would have to be reformatted to meet SABS requirements.

The European standards follow the same basic format as the ISO and SABS standards. It may be possible, through the agreement between SABS and ISO, to arrange for the relevant standards to be used as SABS standards, once they have been amended to suit local requirements. The SABS library keeps ISO and European standards.

The literature survey by Technikon Pretoria [6] indicated that there was a wealth of information on TT. This collaborated and added to the information from ISTT. It was significant that no reference could be found to a set of TT standards in the format envisaged for this project. Other sources of information will be put to use to supplement the above when the standards are being produced.

Table 8 shows that the sources of information needed to either amend or produce 36 of the 40 standards required have been identified.

TABLE 8 : Source of Information/Existing Standards to Produce/Ammend Standards Needed

Activity	Module	Design	Pipe	Material	Service	Construction
NEW CONSTRUCTION	1.0					
Auger boring	1.1	*	SABS			Other
Directional drilling	1.2	*	SABS			Other
Micro-tunnelling	1.3	*	SABS			Other
Moling	1.4	*	SABS			Other
Pipe jacking	1.5	SABS	SABS			SABS
Pipe ramming	1.6	*	SABS			Other
REPLACEMENT	2.0					
Bursting/splitting/cracking	2.1	*	SABS			Other
Eating/reaming	2.2	*	SABS			Other
RENOVATION (Liners)	3.0					
Close fit	3.1	ASTM	SABS			ASTM
Cured-in-place	3.2	ASTM		Other		ASTM
Preformed liners	3.3	*		Other		Other
Sliplining	3.4	ASTM	SABS			ASTM
Spirally wound	3.5	ASTM		ASTM		ASTM
Spray	3.6	?		?		?
Mortar	3.7	?		?		AWWA
REPAIR	4.0	*				
In situ	4.1			Other		**
Localised	4.2			Other		***
Restoring bedding support	4.3			Other		***
Re-rounding	4.4					***
SERVICES	5.0	*				
CCTV Inspection	5.1				****	
Leak detection	5.2				****	
Cleaning	5.3				****	
Utility location	5.4				****	
TOTALS	**23**	**7**	**4**	**5**	**4**	**19**

* details for writing design guidelines available from equipment suppliers or contractors

** project specific

*** proprietory systems

**** company's have own procedures

standards not applicable

It is significant that there are SABS standards for all the pipes currently used in TT installations, but that none of these have any clauses or tests that address the requirements of these pipes to cope with the stresses developed during installation using TT. The ASTM document [5] covers nearly all the standards needed for renovation, and these had been specifically written for TT installations.

It should be noted that the totals given below each column are sometimes less than the number of items in the columns because more than one would be covered by a single standard.

The objective to establish the sources of information needed to produce or amend standards has, thus been achieved.

5.2 Status of TT in South Africa

As a result of changing the modus operandi from person-to-person interviews to telephonic/electronic, the number of responses from both the marketplace (27) and from SASTT members (34) exceeded the 20 planned for each.

Although the sample sizes were small, the response rate was very good. The interviewees were selected to give a representative cross-section of decision-makers from users, ie local authorities and utilities, and providers of TT installations and services in Gauteng.

The questionnaires were structured so that the categories, with question numbers in brackets, corresponded with the elements of objective (ii), namely:

(a) Awareness of the technology (4)
(b) Frequency and reasons for using it (5 & 6)
(c) Range of activities (7 to 12)
(d) Who makes the technical decisions (13)
(e) What technical decisions are made and the products and specifications used (14 to 16)
(f) Views of users and providers about standards (17 to 20).

In addition, the individual questions were worded so that they could be quantified and give a relative measure of the status of TT in Gauteng Province. From the limited contacts made in Cape Town and Durban, it would appear that the views expressed were similar and that it is realistic to take the responses obtained from Gauteng as representative of the other urbanized areas in South Africa.

The graphic representation of the interviewee responses to each question and the comments on each of these graphs gives a clear picture of the views held by a sample of TT providers and users in South Africa. In so doing, objective (ii) and its elements have been met.

5.2.1 Marketplace responses

Much of the information provided by this analysis is self-explanatory. However, discussion about and conclusions that can be drawn from most of the responses are warranted and follow.

Awareness of TT (Question 4) : It should be appreciated that these questions were put to senior persons in technical positions in large organisations. Had the interviewees been in political or administrative positions and in smaller organisations, the awareness level would probably have been much lower.

This indicates that there is considerable scope for increasing the awareness of TT and the benefits it offers.

Reasons for use of TT (Question 6) : Although the dominant reason for using or not using TT is economic, social and environmental factors are considered almost as important. Other reasons for using or not using TT were given by 30% of the respondents. Those given for using TT are:

- to avoid traffic disruption (2)
- to limit roadway damage
- for practical considerations
- to avoid other services
- when there was no other alternative
- local authority requirement.

These comments again indicate scope for increasing the awareness of TT and the benefits it offers.

A reason given for not using TT was lack of local expertise. This comment emphasizes the importance of development and training.

Trenchless techniques used (Question 7) : There is an overlap between guided boring and directional drilling. Internationally, the two terms are considered interchangeable. However, the latter is the most frequently used. Hence, the responses for these two activities have been combined.

In the developed world, the dividing line between jacking and micro-tunnelling is also becoming blurred. However, in South Africa, micro-tunnelling has not established itself yet. Hence, the two responses are recorded separately.

Pipe jacking is the trenchless technique with which the marketplace is most familiar. However, the frequency of use is not nearly as high as in the developed world. In Europe, about 20% of the concrete pipe manufactured is installed using this technique or microtunnelling. In South Africa, the figure is estimated to be between 2 and 4%.

Directional drilling is a growth market in Europe and North America, with significant developments in extending the use of this technique for installing new services of larger diameters over longer distances. There is apparently an increase in the use of this technique in South Africa and, on the questionnaire, it ranks as the second most frequently used technique.

On-line replacement (Question 8) : The only on-line replacement techniques offered commercially in South Africa are pipe bursting and pipe splitting, which are grouped together as they do the same thing. The distinction between them is that the bursting system uses an expanding head that works

effectively on brittle pipe, but not on flexible pipes. For the latter, the system used has a cutting and expanding head that splits the pipe open.

Pipe eating is affected by using micro-tunnelling equipment to crush an existing pipe and discharge the waste. This has not yet been used in South Africa.

Both these replacement techniques involve pulling or pushing in a new pipe immediately after the hole has been made. This part of the process is essentially the same as sliplining, which is covered in Question 9.

Pipe reaming is described in the ISTT guidelines [3, p.54] as an on-line replacement technique. However, it is really part of a renovation technique as it involved removing the deteriorated inner part of the wall thickness only and then applying one of the lining techniques to restore the pipeline to a serviceable state.

Attempts have been made in South Africa to ream out the inside of a concrete pipe, but the technique is not commercially available in this country as yet. The technique has recently been introduced commercially in Europe.

Renovation (Question 9) : The various renovation techniques are meant for different applications, a lack of knowledge of their features could result in them being incorrectly selected and used.

Sliplining results in a significant reduction in pipeline ID and is, therefore, generally not suitable for gravity systems. Its application is for pressure lines or the lining that followed pipe-cracking/bursting, where the conduit is upsized or the product pipe pulled through the hole made by directional drilling.

Cured-in-place liners are suitable for gravity systems because they fitted closely to the pipe ID. In addition, the smoother bore usually compensates for the slight reduction in ID. As these liners were soft when inserted into a pipeline, they conformed to the pipe's shape when expanded and cured and were able to cope with an irregular surface, misalignment and bends.

As the materials used for both slip-lining and cured-in-place linings are impermeable, they prevent infiltration into and exfiltration from the renovated pipeline. The liners, therefore, have to be designed to handle groundwater pressures. From discussion with the interviewees, it is clear that these factors were seldom considered when choosing a renovation method.

The above indicate that there is a very real need for design guidelines to evaluate and select renovation systems.

Spray-lining and mortar lining, have been grouped together as they are both used for corrosion protection of steel pipes in new installations and old installations being renovated.

There were no responses from industrial users of piping systems where there is the need for other types of spray-lining materials, such as epoxies and paints.

Repair (Question 10) : Only 13 (48%) of the respondents had been involved with repairs. For all intents, the only techniques used are in situ and localized, which were both applicable to man-entry pipes, as only two of the respondents had used any other techniques.

As infiltration into South Africa's aging sewer reticulation systems is a serious problem (reportedly accounting for as much as a third of the flow in many of the country's sewers), there is potential scope for using repair techniques developed elsewhere for nonman-entry pipes.

Inspection and location of services (Question 11) : Some CCTV inspection, cleaning and leak detection is carried out by local authorities themselves.

If the use of directional drilling increases, there will be a corresponding increase in the use of locating equipment to track the progress of drilling heads.

In discussions with representatives of the two companies that specialise in CCTV inspections, both emphasized the need for a common basis of classifying the condition of and defects in pipelines and specifying what was required of the survey.

Other techniques (Question 12) : In terms of what is available internationally, there are many techniques for renovating and repairing pipelines which are not used in South Africa. As many of these are applicable to nonman-entry pipelines, there is potentially a demand for their use. However, most of these techniques are proprietary systems. Before they are used in South Africa, it would be desirable to have a means of evaluating them via a set of guidelines.

Design of trenchless installations : Although respondents represented senior technical decision-makers in large reputable organisations, the responses show that there was not a consistent approach to the design and specification of either trenchless installations or the products used in them. This is illustrated by the responses to the individual questions.

Design of trenchless installations (Questions 13) : The fact that 22% of the respondents, including consultants, were prepared to accept the design of trenchless installation by the contractor or just accept it without design justification should be of real concern to decision-makers. This could have serious repercussions with non-performance. The above emphasizes the importance of adequate design guidelines for TT installations.

Buried structures and pipelines in particular need to be designed and specified to carry the actual loads imposed on them as they are very sensitive to the soil-pipe interaction from different installation conditions. For rigid pipes, such as concrete, a misunderstanding of this can result in

actual loads being three times higher than assumed; for flexible pipes, such as plastics, the impact of misinterpreting installation conditions can be much more severe.

Details specified (Question 14) : The primary decision for any pipeline is capacity, which is directly related to actual ID. However 56% of the respondents specified ND and 26% only specified minimum ID. Most TT renovation techniques result in a significant reduction in pipe ID. The need for maintaining actual ID is frequently the reason for using on-line replacement and simultaneous upsizing rather than renovation.

With trenchless installations, whether new, replacement or upgrading, the actual ID and strength of pipe are significant because the former will determine the actual hydraulic capacity of the system and the latter the ability of the new pipe to carry the loads imposed on it, both during installation and while in service.

In South Africa, most of the current TT work is on sewers (gravity systems) where the capacity can't be improved by increasing the pressure. Hence, the actual ID is a critical factor. What's more, on replacement and renovation projects, where the new pipe is invariably one of the plastics, buckling of the pipe due to external groundwater pressure has to be considered, rather than the ability to carry internal pressure.

These facts all reinforce the statement in the commentary on Question 13 about the importance of design guidelines.

Product specifications used (Question 16) : The majority of respondents specified a product but did not link this to a national standard. As the respondents were all in a technical decision-making capacity (±50/50 client/consultant) the answer to this question indicates that the SABS standards for products are seldom used for trenchless installations. This could be because they do not meet the designer's/specifier's requirements (See comment on Question 17).

Trenchless technology standards : There was a very favourable response to these questions, which indicated that there was a demand for national TT standards and that the production of these would be supported.

Standards used (Question 17) : Those respondents that didn't specify any standards or that specified other standards all indicated that they would use national standards if these were available (See Question 18).

The indication in the response to this question and to questions 14 and 15 was that the national standards used were, with three exceptions, product standards. The three exceptions all referred to the use of 1200 LG for the jacking of concrete pipe, which was the only national standard for the trenchless installation of pipe.

The fact that so many of the respondents had either used project specific, or their own specifications for work where there were no national standards indicated that there was a very real demand for these.

Additional comments (Question 20) : A full listing of these comments, edited to remove organisation names, is given in Appendix B7. These have been condensed and combined into the following:

- There is scope for using TT to a far greater extent for the rehabilitation of sewers and to avoid traffic and environmental disruption.
- National standards on all aspects of TT are needed to assist clients in the evaluation of projects.
- Local authorities should be supporting the production of TT standards, both technically and financially.
- Non-TT users need to be encouraged to use these techniques.
- The use of TT is being investigated by those not currently using it.
- Priorities for producing standards are:
  Design guidelines
  Pipe-cracking/sliplining
  Pipe/joint systems
  Directional drilling
  Cleaning
  CCTV inspections
- Topics to be included in the guidelines are:
  - design
  - specifications available
  - compiling working documents
  - measurement and payment.

5.2.2 SASTT Member Responses

Much of the information provided by the graphic presentation of the questionnaire analysis is self-explanatory. Where warranted, discussions about and conclusions that can be drawn from the responses follow.

A factor not addressed by the questionnaire is the geographic location of TT contractors and service providers. From the SASTT address list, it can be seen that the members interviewed are based either in Gauteng (28; 80%), Western Cape (7; 20%), or Durban area (2; 6%). However, some of the members do have branches elsewhere and operate nationally.

Range of activities (Question 3) : These responses cover involvement by all parties in the TT industry. Suppliers could be divided into four materials' suppliers, from whom there were six responses and four equipment suppliers from whom there were four responses. The materials offered were concrete, HDPE and clay. The equipment covered almost the full range used by the contractors.

A more realistic evaluation of what the industry can offer is given by the responses to questions 7 to 12 show what activities the TT contractors offer.

Perception of knowledge about TT (Question 4) : This question endeavours to gauge the perception that the various players in the TT industry have of the other players. In this question, it is the responses that are measured, not the sources of the responses.

A detailed evaluation of these responses showed considerable bias in favour of the respondent to their own particular category, ie the suppliers were of the opinion that they were well aware of TT and the other categories were not; likewise, with the consultants and contractors.

Despite the obvious bias expressed, it is quite clear from the responses to this question that the various categories of players in the TT industry have a lack of confidence in the other players in the industry.

A standard set of documents to which all categories within the TT industry have contributed and, therefore, find acceptable, will help to alleviate this bias, as well as providing an accepted means of communicating and evaluating projects.

Prescription/specification/request/motivation of TT work (Question 5) : It is significant that 24 (71%) of the respondents stated that the TT work was initiated by themselves. This applied to all the categories:

- 10 of the 14 contractors (71%)
- 6 of the 10 suppliers (67%)
- 6 of the 7 consultants (86%)
- both of the local authorities (100%).

This means that companies in all the categories are pro-actively looking for work using TT alternatives and being successful in obtaining it.

Reasons for using TT (Question 6) : Among SASTT members, the choice for using TT was generally based on a combination of factors, with social and environmental factors being considered more important than economic ones.

Trenchless techniques used : As five of the consultants did not respond to this question, the comments made by others who are not contractors have been excluded from the evaluation.

Hence, the number of responses to this question has been reduced from 34 to 14. This gives a more realistic evaluation of the capability of the TT industry in terms of meeting marketplace requirements.

New construction (Question 7): Directional drilling is offered by 6 (43%) of the respondents, but in certain instances the drilling rig is shared between branches of a company (writer's note). It should be noted that once the hole through the ground has been made, a pipe is pulled through this, forming a conduit. There are several companies, who are not SASTT members, that offer these techniques (writer's note).

Although micro-tunnelling is offered by three of the respondents, this equipment is currently not being used.

On-line replacement (Question 8) : The only on-line replacement technique currently used in South Africa is pipe-splitting/cracking, which is offered by five companies. It should be noted that, once the old pipe has been broken, it is immediately replaced by pulling in a pipe that is either continuous or incremental, using the sliplining process.

The note about pipe-reaming given under 5.2.1 Question 8 is equally applicable here.

Repair (Question 10) : Two of the local authorities also did their own in situ repairs and one had done the restoration of bedding support.

The very low proportion of respondents who do repair work indicates that there is little planned inspection and maintenance of services. As a result, minor problems that could be addressed by localised repair work go undetected. These problems become progressively worse and the service eventually becomes so bad that renovation or even replacement become necessary. This is particularly applicable to sewers, which account for most of the on-line replacement and renovation in South Africa.

Inspection and location (Question 11) : Although all the contractors that offered this type of work had CCTV cameras, it would appear that only two offered CCTV inspections as a stand-alone service. The others used this equipment mostly on their own projects.

The local authorities used their own CCTV and leak-detection equipment. Leak-detection and cable and pipe detection equipment was available from local suppliers and these services were offered, although not by any of the contractors who responded. A noteworthy technique not offered by any of the contractors, which appears to be used on an increasing basis internationally is the sonar survey of pipes that are flowing full or partially full. This is particularly useful in determining pipe dimensions, even when the bottom of a sewer is silted.

Design of trenchless installations (Question 13) : Of those who did the design themselves, 57% also relied on others for assistance. However, 50% of the contractors claimed to do the design on their own without outside assistance.

The respondents who stated that the design was done by others were either suppliers, who would not do installation design, or contractors who did the design in conjunction with others.

Although the responses on this topic represent only a sample of what happens in general practice, they do indicate that the approach taken with TT design does not conform to accepted practice in the civil engineering industry. The accepted practice is that the consultant does the design, or in the case of temporary works or construction activities, checks the contractor's design.

These facts are disturbing, as the contractor is taking responsibility for the design as well as the construction of the project. It also emphasizes the need for design guidelines that are accepted by all parties, so that there is a common basis for doing designs and evaluating them.

Details specified (Question 14) : The information provided probably all relates to gravity systems, mostly sewers.

When sliplining or pipe-pulling is to be done, the pipe pressure requirements are specified to cope with pulling forces. Other details sometimes specified or that some of the respondents thought should be specified are:

- chemical resistance
- joint details
- installation length
- site geology.

The scoring in this question shows that the respondents consider the specification of these details important. The additional items raised are significant and should be addressed in any future standards (guidelines or codes).

Installation specifications used (Question 16) : The fact that so many of the respondents specified product details and so few actually specified installation standards indicates that the latter are not available. This situation is even worse when it is considered that four of these used 1200LG for jacking. In effect, there are only seven (25%) of those not involved with jacking who use an installation specification. It would appear that the details of how the installation is done are left to the contractor.

Under these circumstances, it is not surprising that many clients and consultants did not want to use TT.

Organisation views on standards (Question 18) : The response to this question was very good, indicating substantial support by the organisations represented by the respondents for the production of TT standards.

Respondents' views about project (Question 19) : The answers to this question indicated the support of the individual respondents for the production of TT standards.

Additional comments (Question 20) : The fact that 14 (41%) of the respondents added comment to their questionnaires shows substantial support for the development of TT standards.

5.2.3 Responses from Other Organisations

The effort of identifying the relevant technical decision-makers in government departments was not particularly successful.

The contact made with persons responsible for managing the production of standards was fruitful and the following established:

- TC 5120.61 had a system in place for gaining SABS approval of construction standards (1200 series) within a few months.
- TT construction standards could fit into the SABS 1200 series.
- Product/material standards would not fit into the SABS 1200 series, but could probably be processed along similar lines by amending the relevant SABS standard.
- Although the need for a design standard was appreciated, there were no definite views about how this should be addressed (See Section 5.3.1).

It had been suggested that a particular TT activity be selected as a pilot project. The production of an activity module covering pipebursting/splitting, CCTV inspection and sliplining, was selected for this purpose.

The objective to establish how TT standards could be produced using the structures and procedures already established in South Africa was achieved by obtaining this information.

5.3 Framework for TT Standards

The framework developed covers:

- decision-making levels in selecting and specifying TT work
- a full listing of the TT activities currently available in South Africa
- the standard format for SABS documents
- the section headings required for the different types of standard.

When a new TT activity is introduced to South Africa, a new activity module can be produced and the components added as system standards.

The use of activity modules will ensure that all aspects of a particular trenchless technique are covered by standards and that these standards together with explanatory notes are available as a set of documents.

Although there are 23 different TT activities listed in the framework and there needs to be a module for each one of these, there is an overlap with the products/materials used and the design criteria are the same. This means that a system standard for a product or material could be used in several modules. On the other hand a system standard for design (code of practice) would cover several modules. Hence, the evaluation given in Section 4.3 about the availability of TT standards from elsewhere and in Section 4.4 about the work needed to produce the full set of standards show that only 40 documents are required and not 56 as would be obtained by adding the totals from Table 3. When the guidelines are combined into codes of practice there will be 35 standards covering the current TT activities. Almost all of these will be new standards, based on similar documents already produced elsewhere.

5.4 Design Standards

Initially, it was thought that the TT design standards should be incorporated in SABS 0102. This would mean that the selection of all pipe types and rehabilitation methods for the full range of installation conditions would be covered by a single document written with the same design philosophy. However, there would be a serious flaw in this approach, as SABS 0102 covers the selection of pipe strength and doesn't cover pipe size, durability, joints, and other long-term factors that are essential when considering rehabilitation. An additional consideration is that TT involves both the installation of new services and the rehabilitation of old pipelines.

If all these factors were considered in a single document covering both the installation of new services using open cut and TT and the rehabilitation of old pipelines using TT, this document and its parts would become cumbersome and it would become time-consuming for the user to extract the relevant information for application to a specific problem.

It makes sense, therefore, to include the selection of pipe strength for the TT construction of new installations in the relevant parts of SABS 0102, and to produce a new stand-alone code of practice that addresses all aspects of selecting rehabilitation systems for old and deteriorating pipelines. This document could probably draw a significant amount of its content from the initiative to reconcile and update different national approaches in Europe and North America (Dr J Gumble[11] – See page 8 of this report) through the agreement between SABS and ISO.

An interim measure would be to produce the design guidelines for each technique or group of techniques and release these simultaneously with the construction and product/material standards as an activity module as detailed in Table 3.

These individual guidelines could be combined at a later stage into design guidelines as detailed in Section 4.3. Ultimately, they would be used for the additions to SABS 0102 and in producing the code of practice for the rehabilitation of pipelines, as detailed above.

5.5 Development of TT Standards

Section 4.4 lists what documents are needed to produce a full set of TT standards. However, it does not detail what has to be done and the resources required, as these are outside the scope of the present study. It is envisaged that they would be addressed through subsequent activities.

5.6 Technology Transfer

The process of researching and producing this report, in itself, has transferred knowledge to the steering committee and working group members.

However, the actual production of standards will provide the opportunity for students to gain further qualifications by researching and combining international standards and publications into relevant standards for South African conditions. As this would be done under supervision at an academic institution, both students and mentors would benefit from the exercise. This mode of technology transfer would be sustainable and would have far-reaching benefits for the country in that:

- The academic institution would be involved with TT on a continuous basis and would thus be able to forge links with international academics who are on the cutting edge of development in the field.
- Supervisors would accumulate knowledge and be in a position to act as consultants to both the demand and supply roleplayers in the TT industry.
- Students who acquired the qualifications would look for employment opportunities in the TT industry and would have to apply their knowledge to the workplace.

Most TT activities are non man-entry, either due to their size or the fact that the activities preclude the concurrent presence of workers. Hence, the activities are remotely controlled and monitored from the surface. This type of work requires operators with the necessary skills and experience. Operators will need job specific training and, if the requirements of the Skills Development Act are to be met, certification. These comments are equally applicable to the persons supervising the work and monitoring its quality.

Prerequisites for this training and certification are:

- accredited courses that form part of a national qualification
- accredited trainers to run the courses
- centres where the courses can be conducted
- standards on which the courses can be based.

This project addresses the latter issue. An awareness campaign, outside the scope of this study, to promote the use of TT standards would initiate the transfer of this technology to potential users, designers and specifiers.

Most TT contractors in South Africa are small owner managed businesses. In general, they do not have the resources to offer the above training in-house and would need to outsource this function, which could well be to the academic institution that played a role in developing the standards.

The above combination of factors indicates that the transfer of TT knowledge within South Africa would flow from the project initiated by this consultancy.

6. CONCLUSIONS

6.1 Availability of Information

South African National Standards : Only one trenchless activity is covered by South African National Standards, namely (concrete) pipe jacking, and this coverage is only in part.

International Standards : The most significant of these appear to be the ASTM publication, which combines all its standards pertaining to TT under one cover, and the European Standards for renovation systems, which are currently being compiled.

The Literature Survey : This focused on a web search and indicated that there was a wealth of information on TT, but that this was somewhat fragmented.

ISTT : There are several publications containing a lot of qualitative information about TT that can be used for guidelines, but not directly for standards.

Correspondence with ISTT and Affiliates : This established contact and initiated some offers of guidance and assistance.

6.2 Status of TT in South Africa

Response to questionnaires : This was very good, with a 79% reply rate from the marketplace and an 85% reply rate from SASTT members.

Awareness of the technology : Although the respondents in the marketplace knew about TT in general, their detailed knowledge appeared to be limited. This was confirmed by the views expressed by SASTT members.

Frequency and reasons for using TT : In general, TT appears to be used when there isn't much alternative. The marketplace puts economics as the most important reason for using or not using TT, whereas the SASTT members gave social and environmental reasons.

Range of activities : Although all categories of TT activity are used in South Africa, there are many of the techniques themselves that are not, ie only about half the renovation techniques available internationally are offered locally.

Trenchless decision-makers : A significant proportion of TT designs appear to be done by the contractors themselves. This raises the question of technical responsibility that is traditionally taken by the consulting engineer.

If projects are handled on a design and construct basis, which makes sense when specialist contractors are employed, in their own interest clients should arrange an independent check on the design and quality of workmanship. Under these circumstances, standards are essential to ensure that there is a common basis for communication.

Technical decisions : In many instances, it would appear that the technical decisions that are made are inadequate, eg nominal pipe diameter is frequently specified instead of actual minimum internal diameter.

Products specified : Although concrete, HDPE and steel are the products most frequently specified, the relevant SABS Standards are apparently seldom specifically specified.

TT Standards : The standards most frequently used appear to be project specific, suggesting that other standards are either not available or are inadequate.

Views on TT Standards : The production of National TT Standards would be welcomed as indicated by the fact that all the marketplace respondents and 85% of the SASTT respondents said that they would use them if they were available. Moreover, there was support for producing standards as indicated by the offers of assistance and additional comments made.

6.3 Production of TT Standards

Standard Specifications for TT Construction : These could be produced using the structure and procedures already prepared by the 1200 Series Technical Committee.

Standards for products/materials and methods : These could be produced following the same procedures and a similar structure to that prepared for the 1200 series.

Codes of practice : A separate code for each TT activity would be impractical. Production of guidelines would be preferable so that an activity module could be prepared for each TT activity. These design guidelines could be compiled as a code of practice for the rehabilitation of pipelines at a later stage.

SABS 0102 : This code of practice for the selection of pipes for buried pipelines should be amended to include sections for determining the strength of pipes installed by means of TT techniques.

6.4 TT Standards Currently Required in South Africa

Currently, 40 documents are required. Of these, 32 would be produced as national standards and the balance as guidelines. The latter would be combined at a later stage to produce three national codes of practice.

Priorities for producing these standards are established and a pilot project initiated for a grouping of activities, namely CCTV inspection, cleaning, pipe bursting/splitting, and sliplining, which are frequently used in combination.

6.5 Framework for TT Standards

This gives a logical approach for developing standards using the structures and procedures already established and encourages the simultaneous publication of all standards related to a given activity module. It is structured so that additional activities can be added as and when required.

6.6 Final Comment

TT is an environmentally sound, socially acceptable and economic set of techniques for installing new and rehabilitating existing water services and other buried services in high-density urban areas. By ensuring that the "clean water stays in the clean water pipes and the dirty water stays in the dirty water pipes", it thus has potential for making a significant contribution to the health of the communities where it is used without the negative consequences of open trenches in densely populated areas.

There are several factors influencing the South African TT industry that need to be appreciated, namely:

- In a global context, the South African TT industry is small and its development is dependent upon the transfer and adaptation of technology from the first world.
- There is a serious shortage of knowledge and skills in the construction industry as a whole, which sometimes compromises the quality of decisions and workmanship.
- Empowerment and skills transfer are essential if the TT industry is to meet the increasing demand for their services.
- Training and development, which take time and effort, need to be based on effective communication and sound principles.

The first two factors explain why, at times, there is inadequate attention paid to the design and specification of TT installations, resulting in the extremes of:

- conservative over-specification and unnecessary expenditure
- risky under-specification and unexpected failures.

They also explain why it is necessary to have an effective system that documents the correct way of selecting, designing, specifying, and constructing TT installations, and provides the means of verifying that these activities have been correctly performed.

A set of national standards that takes into account local standards of education, conditions on site, and is easily understood will provide an effective means of communication, which is essential to the effective quality management of technical decisions and site workmanship; for any training and development initiatives; and for the resolution of any problems that may arise.

7. RECOMMENDATIONS

7.1 Recommendations Specific to this Investigation

(i) Distribute this report to various parties involved in producing national standards.

(ii) Use the framework developed to motivate the development of TT standards and guidelines.

(iii) SASTT should produce a directory of TT services based on the framework.

7.2 Planning & Research Recommendations to Produce TT Standards & Guidelines

(i) Formulate a detailed plan for the production of TT standards based on:

- The framework in this report
- A review of the information sources identified.

This would cover priorities for producing the standards; what research was needed; how this would be achieved; and possible sources of funding.

(ii) Formalise the relationship between the TT steering committee and the SABS Technical Committee handling the 1200 series and agree upon the structure of the TT standards.

(iii) Produce a document which explains how to use the TT standards during the various stages of a project.

7.3 Recommendations For the Overall Project

(i) Implement a plan for producing the required TT standards.

(ii) Establish a chair for TT at Technikon Pretoria, which will serve to initiate

- research and development aimed at transferring and adapting international technology to South African conditions
- capacity building and skills/technology transfer for a developing industry.

(iii) Initiate the process of having the uncompleted sections of SABS 0102 written.

(iv) Monitor the pilot project on CCTV inspection; cleaning; pipe bursting/splitting and sliplining, using the activity modules developed as a model for future modules.

(v) Maintain contact with ISTT affiliates who corresponded and offered guidance.

(vi) Maintain contact with interviewees who requested this and those who offered to comment on standards being produced.

(vii) SASTT should embark on an awareness campaign of press releases, publications and mini-seminars.

GLOSSARY OF TERMS

Auger Boring : A technique for forming a bore from a drive pit, by means of a rotating cutting head. Spoil is removed back to the drive pit by helical auger flights rotating in a steel casing. The equipment may have limited steering capability. See **Guided Auger Boring**.

Auger TBM : A type of **Tunnel Boring Machine** (TBM) in which the excavated soil is removed to the drive shaft by auger flights passing through the product pipeline pushed in behind the TBM.

Back-reamer : A cutting and/or expansion tool attached to the leading end of a Drill String, which enlarges the **Pilot Bore** during a **Pull-Back** operation to enable the **Product Pipe** to be installed.

Bent Sub : An offset section of drill stem close behind the Drill Head that allows steering corrections to be made by rotating the **Drill String** to orientate the drill head. Frequently used in **Directional Drilling**

Can : A principle module that is part of a **Shield Machine** as in **Microtunnelling**. Two or more may be used, depending on the installation dimensions required and the presence of an articulated joint to facilitate steering.

Carrier Pipe : A defective pipe to be rehabilitated by any trenchless method.

Cased Bore : A bore in which a pipe, normally a steel sleeve, is inserted simultaneously with the boring operation. Usually associated with **Auger Boring**.

Casing : A pipe to support a bore. Usually not a **Product Pipe**.

CCTV : ***Closed Circuit Television*** *used to carry out internal inspections and surveys of pipelines.*

Chemical Stabilisation : Renovation work which involves the sealing of a length of pipeline between two access points by introducing one or more compounds in solution into the pipe and surrounding ground if necessary, producing a chemical reaction. Such systems may perform a variety of functions such as sealing of cracks and cavities, the provision of a new wall surface with improved hydraulic characteristics or ground stabilisation.

Close-Fit Lining : A lining system in which the new pipe makes close contact with the defective pipe. Typical techniques are those in which the liner is temporarily reduced in size by **Swaging** or folding, and is reverted to its original size after insertion into the **Host Pipe**.

Crossing : Trenchless installation in which the primary purpose is to provide one or more passages beneath an obstruction.

Cured-In-Place Lining : A system in which a flexible, fabric tube is impregnated with resin and forced into position against an inner wall of a defective pipeline or other conduit before curing the resin to harden the material. The uncured lining may be installed by winch or inverted by water or air pressure. Linings may be structural or supplementary to the existing pipeline.

Cured-In-Place Pipe (CIPP) : An alternative term for **Cured-in-Place Lining**, usually implying structural renovation.

Cutting Head : An tool or system of tools on the end of the **Drill String** that excavates at the face of a bore. Usually applies to mechanical methods of excavation. Also referred to as the **Drill Head**.

Deformed And Reshaped Liners : An alternative description of liners that are temporarily reduced in overall size during insertion, and then reverted close to their original size. See **Close-Fit Lining**, **Swaged Liners** and **Fold & Form Liners**.

Directional Drilling : A steerable system for installation of pipes, conduits and cables in a shallow arc using a surface-launched drilling rig. Traditionally the term applies to large-scale crossings in which a fluid filled pilot bore is drilled without rotating the **Drill String**, and this is then enlarged by a **Washover Pipe** and **Backreamer** to the size required for the **Product Pipe**. The required deviation during pilot boring is provided by the positioning of a **Bent Sub**. Tracking of the **Drill String** is achieved by the use of a downhole survey tool. The term **Directional Drilling** and **Guided Boring** have more recently tended to overlap, the latter formerly referring to smaller-scale equipment and applications. The term Directional Boring is also used by some exponents, and it is probably unwise nowadays to infer anything about the scale of the operation from the terminology.

Drill Head : An alternative term for **Cutting Head**.

Drilling Fluid/Mud : A mixture of water and usually bentonite or polymer continuously pumped to the **Cutting Head** to facilitate the removal of excavated material, stabilise the bore hole, cool the head and lubricate the installation of the **Product Pipe**. In suitable ground condition water alone may be used.

Drill String : The entire span of drill pipes or rods connected together between the drilling machine and the **Cutting Head**.

Drive Shaft/Pit : Chamber or excavation from which trenchless equipment is launched for the installation or renovation of a pipeline, conduit or cable. It may incorporate a **Thrust Wall** to spread reaction loads to the ground. Also known as **Entry Shaft/Pit** or **Launch Shaft/Pit**.

Dry Boring : Any drilling system not employing **Drilling Fluid**. Usually associated with guided **Impact Moling**, but also with some rotary methods.

Earth Piercing : An alternative term for **Impact Moling**.

Earth Pressure Balance (EPB) Machine : Type of **Microtunnelling** or tunnelling machine in which mechanical pressure is applied to the material at the face and controlled to provide the correct counterbalance to earth pressure in order to prevent heave or subsidence. The term is usually not applied to those machines where the pressure originates from the main **Pipe Jacking** rig in the **Drive Shaft/pit** or to systems in which the primary counterbalance of earth pressures is supplied by pressurised **Drilling Fluid** or slurry.

Entry/Exit Angle : In a **Directional Drilling** or **Guided Boring** system, the angle to the ground surface at which the **Drill String** enters and exits in forming the pilot bore.

Entry Shaft/Pit : An alternative term for **Drive Shaft/Pit**.

Exit Shaft/Pit : Chamber or excavation into which trenchless technology equipment is driven and recovered following the installation or renovation of the **Product Pipe**, conduit or cable. Also known as **Reception Shaft/Pit**.

Expander : A tool that enlarges a bore during a **Pull-Back** operation by compression of the surrounding ground rather then by excavation. Sometimes used during a thrusting process as well as during pull-back. The term may be applied to a bursting head used to break out an existing pipe during **On-Line Replacement**.

Ferrocement : Materials comprising cementitious and steel elements either placed in situ by **Man-Entry** work to form a structural lining, or pre-formed into segments for later installations.

Fluid Assisted Boring/Drilling : A type of **Guided Boring** technique using a combination of mechanical drilling and pressurised fluid jets to provide the soil cutting action.

Fluid Jet Cut : See **Jet Cutting**.

Fold And Form Liners : A term used to describe some systems in which the liner is folded to reduce its size during insertion, and then reverted to its original shape by the application of pressure and/or heat. See **Close-Fit Lining**.

Free Boring : **Auger Boring** without a **Casing**.

GPR : **Ground Penetrating Radar**, used to locate sub-surface discontinuities from ground level or from within a pipeline.

Grouting : Filling of the annular space between the **Host Pipe** and the new **Product Pipe**. Grouting is also used to fill the space around the laterals and between the new pipe and manholes. Other uses of grouting are for **Localised Repairs** of defective pipes and ground improvements prior to excavation during new installations.

Guided Auger Boring : A term applied to **Auger Boring** systems that are similar to **Microtunnelling**, but with the guidance mechanism actuator sited in the **Drive Shaft** (eg a hydraulic wrench which turns a steel casing with an asymmetric face at the cutting head). The term may also be applied to those auger boring systems with rudimentary articulation of the casing near the head activated by rods from the drive pit.

Guided Boring : A steerable system for the installation of pipes, conduits and cables using a surface- or pit-launched drilling rig. A **Pilot Bore** is drilled by a rotating **Drill String** and is then enlarged by **Back Reamer** to the size required for the **Product Pipe**. The necessary deviation during the pilot boring is provided by an asymmetric drill head, eccentric fluid jets or a combination of both, usually in conjunction

with a **Locator**. Although originally referring to different ends of the market, the terms **Guided Boring** and **Directional Drilling** are nowadays often treated as interchangeable.

Horizontal Directional Drilling (HDD) : See **Directional Drilling**.

Host Pipe : The original pipe into which a liner is installed. Also sometimes known as **Carrier Pipe**.

Impact Moling : The use of a tool that comprises a percussive hammer within a suitable casing, generally of torpedo shape. The hammer may be pneumatic or hydraulic. The term is usually associated with no-steered or limited steering devices without rigid attachment to the launch pit, relying upon the resistance (friction) of the ground for forward movement. During operation the soil is displaced, not removed. An unsupported bore may be formed in suitable ground, or a pipe drawn or pushed in, behind the impact moling tool. Cables may also be drawn in. The term **Earth Piercing** is commonly used in North America as an alternative to Impact Moling.

Impact Ramming : Alternative term to **Pipe Ramming**

Infiltration : Water from the surrounding ground that enters through cracks or defective joints in a pipeline or its lateral connections and chambers.

Infiltration/Inflow (I/I) : The total quantity of water from infiltration and inflow without distinguishing the source.

Interjack Pipes : Pipes specially designed for use with an **Intermediate Jacking Station**.

Intermediate Jacking Station : A fabricated steel shield incorporating hydraulic jacks designed to operate between **Interjack Pipes** to provide incremental thrust on long drives.

Internal Inspection : Means of ascertaining the condition of pipelines, either by **Man-Entry** visual inspection or by the use of remote-control equipment such as **CCTV**.

Jacking Force : Force applied to pipes in a **Pipe Jacking** operation.

Jacking Pipes : Pipes designed to be installed using **Pipe Jacking** techniques.

Jacking Shield : A fabricated steel cylinder from within which the excavation is carried out either by hand or machine. Incorporated within the shield are facilities which allow it to be adjusted to control line and level.

Jet Cutting : A type of **Guided Boring** technique using pressurised fluid jets to provide to soil cutting action.

Launch Shaft/Pit : An alternative term for **Drive Shaft/Pit**.

Lead Pipe : The leading pipe manufactured to fit the rear of a **Jacking Shield** and over which the trailing end of the shield is fitted.

Lining : An internal coating or tube used to rehabilitate a pipeline without excavation.

Live Insertion : Installation of a liner, usually into a gas pipeline, whilst the **Host Pipe** remains in service. Also referred to as **On-Line Renovations**.

Localised Repair : Repair work on a pipe, particularly a sewer, for lengths less than the distance between two access points.

Locator : An electronic instrument used to determine the position and strength of electromagnetic signals emitted from a transmitter sonde fitted behind the **Cutting Head** of a boring system, in an **Impact Moling** tool or from existing underground services. Sometimes referred to as a **Walkover System**.

Maintenance : Improves pipeline performance without incorporating additional fabric, eg cleaning.

Man-Accessible : *Description of a pipe, chamber or excavation that can be entered by an operative,* subject to legal and regulatory constraints. If the size is below the minimum required for **Man-Entry**, regulations may define limitations such as the maximum distance from a safe access point, the time for which access is permitted and the number and location of trained operatives in the support team.

Man-Entry : Description applied to any trenchless process that requires an operative to enter a pipeline, duct or bore. The minimum size for which this is permissible may be defined by local legislation. See also **Man-Accessible**.

Micro-Tunnelling : Steerable, remote control **Pipe Jacking** to install pipes of internal diameter less than that permissible for **Man-Entry**.

Measurement While Drilling : Borehole survey instrumentation that provides continuous information simultaneously with drilling operations, usually transmitting to a display at or near the drilling rig.

Midi-Rig : Intermediate sized, steerables, surface-launched drilling equipment for the installation of pipes, conduits and cables. Tracking of the **Drilling String** may be achieved by either a downhole **Survey Tool** or **Locator**.

Modified Sliplining : An alternative term for **Close-Fit Lining**.

Mole : See **Impact Moling**.

Mole Ploughing : Laying a pipeline by pulling a plough through the ground whilst a continuous length of pipe is fed into the top of the plough and buries it from the tail.

On-Line Renovation : See **Live Insertion**.

On-Line Replacement : The breaking out of an existing pipeline and the installation of a new pipeline on the same line.

Open Cut : The method by which access is gained by the excavation from ground level to the required level underground for the installation, maintenance or inspection of a pipe, conduit or cable. The excavation is then backfilled and the surface reinstated.

Ovality : The difference between the maximum and the minimum diameter divided by the mean diameter at any cross section of a pipeline, generally expressed as a percentage.

Patch Repair : A type of **Localised Repair** in which a short sleeve of resin-impregnated material is positioned within the **Host Pipe** and cured.

Percussive Moling : See **Impact Moling**.

Pilot Bore : The action of creating the first (usually steerable) pass of any boring process that later requires enlarging with a **Back-Reamer** or similar tool. Most commonly applied to **Guided Boring**, **Directional Drilling** and two-pass **Microtunnelling** systems.

Pipe-Bursting : A technique for breaking the existing pipe by brittle fracture, using mechanical force from within, the remains being forced into the surrounding ground. At the same time a new pipe, of the same or larger diameter, is drawn in behind the bursting tool. The pipebursting device may be based on a pneumatic **Impact Moling** tool which converts forward thrust into a radical bursting force, or by a hydraulic device inserted into the pipe and expanded to exert direct radical force. See also **Pipe Splitting**.

Pipe-Cracking : An alternative term for **Pipebursting**.

Pipe-Displacement : An alternative term for **Pipebursting**

Pipe-Eating : A technique, based on **Microtunnelling**, in which a defective pipe is excavated together with the surrounding ground as for a new installation. The microtunnelling shield machine will usually need some crushing capability to perform effectively. The defective pipe may be filled with grout to improve steering performance. Alternatively, some systems employ a proboscis device to seal the pipe in front of the shield.

Pipe Jacking : A system of directly installing pipes behind a **Shield Machine** by hydraulic jacking from a **Drive Shaft** such that the pipes form a continuous string in the ground.

Pipe-Ramming : A non-steerable system of forming a bore by driving a steel **Casing,** usually open-ended, using a percussive hammer from a **Drive Pit.** The soil may be removed from an open-ended casing by auguring, jetting or compressed air. In appropriate ground conditions a closed casing may be used.

Pipe Reaming : Technique for removing the deteriorated inside of a pipe so that sound material remains.

Pipe-splitting : Technique for breaking an existing pipe by longitudinal splitting, at the same time a new pipe of the same or larger diameter is drawn in behind the splitting tool.

Point Repair : An alternative term for **Localised Repair**.

Pre-Conditioning Work : That part of a project, usually before renovation work, which includes **Preparatory Cleaning** and **Internal Inspection**.

Preparatory Cleaning : Internal cleaning of pipelines, particularly sewers, prior to inspection, usually with **Water Jetting** and removal of material where appropriate.

Product Pipe : Permanent pipeline for operational use.

Pull-Back : That part of a **Guided Boring** or **Directional Drilling** process in which the **Drill String** is pulled back through the bore to the starting point, usually installing the **Product Pipe** at the same time.

Pull-Back Force : The tensile load applied to a **Drill String** during the **Pull-Back** process. **Guided Boring** and **Directional Drilling** rigs are generally rated by their maximum pull-back force.

Reception Shaft/Pit : An alternative term for **Exit Shaft/Pit**.

Rehabilitation : Covers any aspect of restoring or improving the functional performance of an existing pipeline system, by maintenance, repair, replacement or renovation. The improvement or restoration of a pipeline by any means, trenchless or otherwise, which incorporates the fabric of that pipeline and is aimed at enhancing its performance and extending its life. Rehabilitation may address structural and/or hydraulic weakness.

Re-instatement : The backfilling, compaction and re-surfacing of any excavation in order to restore the surface and underlying structure to enable it to perform its original function.

Repair : Defined as rectification of local damage, such as sealing of individual cracks or joints.

Replacement : Installation of a new pipeline system, which may be accomplished either by open cut or by one of the trenchless techniques of microtunnelling or pipe-bursting.

Renovation : The term is used to describe methods of improving pipeline performance by lining.

Re-rounding : A preparatory process which involves the insertion of an expansion device into a distorted pipe to return it to a circular cross-section. This is usually carried out prior to the insertion of a permanent liner or supporting band.

Resin Injection : The **Localised Repair** of pipes, usually sewers, by injection of a resin formulation into cracks or cavities, which subsequently cures to prevent leakage and further deterioration, it may also increase the structural strength of the pipeline.

Robot : A remote control device with closed circuit television (**CCTV**) monitoring, used mainly for **Localised Repairs** work such as cutting away obstruction, reopening lateral connections, injecting resin into cracks and cavities, grinding and re-filling.

Rod Pushing : See **Thrust Bore**.

Segmental Lining : The use of prefabricated segments in **Man-Entry** work to form a new lining within the defective pipe. The segments are usually sealed at the joints and the annulus grout-filled to bond with the defective pipe.

Sleeve Pipe : A pipe installed as external protection to a **Product Pipe**.

Sliplining : Insertion of a new pipe by pulling or pushing it into the existing pipe, usually followed by grouting of the annular space. The pipe used may be continuous or a string of discrete pipes. This latter is also referred to as a segmental sliplining.

Soft Lining : An alternative term for **Cured-In-Place Lining.**

Sonar : A pipeline survey technique using high frequency sound to establish the internal profile of a pipe. Most sonar systems are designed to work underwater rather than in air.

Spiral Lining : A technique in which a ribbed plastic strip is spirally (or helically) wound by a winding machine to form a liner which travels up the **Host Pipe** as further turns of the helix are added. The annular space may be grouted or the spiral liner expanded to reduce the annulus and form a **Close-Fit Liner**. In larger diameters the liner may be produced from within the host pipe by manually forming the plastic strip into a helix.

Spray Lining : A technique for applying a lining of cement mortar or resin by rotating a spray head that is winched through the existing pipeline.

SSES : Sewer System Evaluation Survey of tributary sewer systems with levels of **Infiltration and Inflow**.

Survey Tools : Downhole equipment and instruments used to determine the position of a bore in **Directional Drilling** or site investigation.

Swaged Liners : Polyethylene liners whose diameter is reduced prior to insertion by passing them through dies or rollers. This may be carried out in a factory or on site as part of the installation process. Once installed, the liner is reverted to its original size by internal pressure. See **Close-Fit Lining**.

Target Shaft/Pit : An alternative term for **Exit Shaft/Pit**.

Thrust Boring : A method of forming a **Pilot Bore** by driving a closed pipe or head from a **Thrust Pit** into the soil that is displaced. Some small diameter models have steering capability achieved by a slanted pilot-head face and electronic monitoring, generally in conjunction with a locator. Back reaming may be used to enlarge the pilot bore.

Thrust Pit : An alternative term for a **Drive Pit**.

Trenching : An alternative term for **Open Cut**.

Trenchless Technology : Techniques for the installation, replacement, renovation and repair of pipes, ducts, cables, and other underground apparatus with minimum excavation from the ground surface. May also include associated techniques such as leak detection, inspection and location of existing infrastructure.

Tunnel Boring Machine (TBM) : A full-face circular mechanised shield machine, usually of **Man-Entry** diameter, steerable and with a rotary cutting head. For pipe installation it leads a string of jacked pipes. It may be controlled from within the shield or remotely.

Uncased Bore : Any bore without a lining or pipe inserted, ie, self-supporting, whether temporary or permanent.

Upsizing : Any method that increases the cross-sectional area of an existing pipeline by replacing with a larger diameter pipe.

Walkover System : See **Locator**.

Washover Pipe : A rotating drill pipe of larger diameter then the pilot drill and placed around it with its leading edges less far advanced. Its purpose is to provide stiffness to the drilling pipe in order to maintain steering control over long bores, to reduce friction between the **Drill String** and the soil and to facilitate mud circulation. See **Directional Drilling**.

Water Jetting : Internal cleansing of pipelines using jets of water at high pressure.

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LITERATURE SURVEY OF

EXISTING CODES AND STANDARDS ON TRENCHLESS TECHNOLOGY

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PREFACE

In South Africa there are few national codes and/or standards covering Trenchless Technology (TT). The realisation of this lead to a joint venture between Technikon Pretoria and Pipeline Installation and Professional Engineering Services CC to establish a framework within which TT standards can be developed. An essential part of this exercise is a literature survey to establish what standards are available both locally and internationally.

This project is funded by the Water Research Commission (WRC) and has been endorsed by the Southern African Society of Trenchless Technology (SASTT) and two of the largest Local Authorities in South Africa.

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COMMISSION AND OBJECTIVES

Introduction

In South Africa there are few National codes and/or standards covering trenchless technology (TT). This is hindering the growth of the industry as authorities and consultants are loath to specify products or techniques for which there are no standards.

The current South African Bureau of Standards, Standardized Specifications for Civil Engineering Construction (SABS 1200) caters for most civil and structural construction activities and is in the process of being revised. Trenchless construction techniques, with the exception of pipe jacking and materials are not covered in these standardized specifications.

This absence of codes and standards has resulted in a joint venture between Technikon Pretoria and Pipes CC to establish a framework within which technology standards can be developed. This project is funded by the Water Research Commission (WRC) and has been endorsed by the Southern African Society of Trenchless Technology (SASTT) and two of the largest Local Authorities in South Africa.

At present, it is envisaged that this project will take place in three phases, of which the first phase will consist of developing the framework, which is a scoping exercise to establish what standards are available and to identify what TT standards are needed in South Africa.

Objectives of Consultancy

The objectives of this phase is to produce an appropriate framework for establishing a complete set of South African National TT standards with respect to:

- Guidelines for Designing, Selecting and Specifying TT installation would contain more technical information than current European and American Codes, as TT textbooks are not readily available in South Africa and its neighbouring states. Explanations would, therefore, be provided to support the specified formulae and procedures given. However, they would not be written in the style of a textbook. Where necessary, references would be made to source publications and where they can be obtained.
- Standards for Pipes Used in TT Installations would include those made of concrete, ductile iron, fiberglass, high-density polyethylene (HDPE), steel, uPVC, and vitrified clay. SABS, ISO and ASTM Standards already exist for most of these pipe materials. Some could be used directly in the TT standards; others would need amending to ensure that they were appropriate.
- Standards for Materials Used in TT Installations would include those used for coating, sealing, grouting, point repair and lining.

- Standards for Services Used in TT would include CCTV inspection and defect classification, ground-penetrating radar, leak detection, sonar survey and utility location.
- Standard Specifications for TT Installations would cover the full range of site activities, including close-fit lining, cured-in-situ lining, guided boring and directional drilling, impact moling and ramming, localised repair and sealing, micro-tunnelling, on-line replacement, pipe jacking, sliplining and spray lining.

In addition to the aforementioned, measures shall be introduced where feasible:

- To create a TT research forum at Technikon Pretoria;
- To liaise with international organisations on a continuous basis;
- To develop course material on TT to be introduced in the syllabi of graduate and post graduate coursework;
- To disseminate information to the civil engineering fraternity through short courses and seminars.

Commission

The Department of Civil Engineering at Technikon Pretoria has been allocated the task to conduct a literature survey as an element of the scoping exercise. This is the first part of this proposed three-phase project culminating in the production of a comprehensive set of national standards for TT in South Africa.

The objectives of this literature survey are to establish:

- What information on TT standards is available in other countries, i.e. from international organisations who have written TT standards or are in the process of doing so;
- If any National Standards Organisations have produced TT standards or are in the process of doing so;
- Which organisations would be the most likely to be in a position to assist with the project;
- Any other information that could be of value to the project.

METHODS OF INVESTIGATION

Introduction

The main sources of information were used to acquire the relevant information, i.e. the Technikon Pretoria library database, also the Cement & Concrete Institute library in Midrand, the Internet and direct electronic communication with web sites with known addresses. Comment about SABS documents and correspondence with and International Society for Trenchless Technology (ISTT) and affiliates are covered in the main report.

Library

An electronic database was used to acquire publications, dissertation abstracts, research outputs, research colloquiums and articles (1).

Internet

Searches were undertaken on the Internet. Web sites with TT affiliations included:

- Yahoo web site (2),
- TT Societies and Associations (3,7,8,12),
- International standards institutions, such as ISO/ECS and ASTM (4,7),
- TT contracting firms (5,7,10),
- TT product/services providers (7,12,13),
- Bookstores/publications (9,11),
- international TT research centres (6),
- proceedings of international conferences (3,7,11),
- civil engineering web sites, such as the American Society of Civil Engineers and the British Institution of Civil Engineers (11),
- Those suggested by the ISTT (3),
- Water resources and hydraulics web sites, such as the Water Environment Federation (WEF) (8),
- geotechnical web sites (2).

Electronic communication

A number of e-mail questionnaires were sent to smaller web sites. The response generally was poor, however some divulged information promptly. Follow up questionnaires were generally not answered.

Discussion

The search for information was concentrated on North America, Europe and Australasia. However, there is very good co-operation and networking among most organisations in different countries. Most web site databases are linked with one another and

associations exist in most fields, such as research, publications, materials and construction methods.

In a communication with the ISTT it was mentioned that most countries had TT standards on TT of one form or the other based on the degree of sophistication of their construction legislation. Clarification is needed to establish whether these standards are national, industry, association or manufacturer standards, etc. ISTT are of the opinion that the USA, Japan and Germany are the leaders in this field, where there is a common sharing of knowledge and information. The American web sites are generally more user friendly and give by far the most information.

FINDINGS

Introduction

There is a wealth of information on TT available on the Technikon database, the web sites and it is readily accessible on e-mail.

Information on TT

The information available is not exhaustive but covers many issues of interest to researchers, consulting engineers, manufacturers, contractors and owner/operators from planning, design, new construction, rehabilitation, renewal, to inspection and evaluation.

A large number of topics normally covered in standards are also addressed, including:

- Modelling and evaluation
- Assessing pipe conditions
- Local geology and site conditions
- Inspecting pipe and field conditions
- Adopting innovative equipment
- New construction
- Maintenance
- Rehabilitation
- Case studies
- Contracting
- Equipment
- Materials
- Manufacturing.

Standards and specifications on pipe materials and the installation thereof are generally covered by ASTM standards, but there are also proprietary construction specifications. ASTM standards cover the whole spectrum of pipes, namely, concrete, vitrified clay, fibreglass pipe, steel pipe, ductile iron pipe, glass reinforced concrete, PVC, polyethylene and rehabilitation. These have been collected in a single publication (14). No evidence of a similar comprehensive set of specifications and standards in the UK or Europe was found.

The Societies on TT in the various countries cover most aspects of standards and specifications in this field in association with other bodies and learned societies on an ad hoc basis.

A number of project specifications and tender documents are available from a trenchless sewer specialist through the Directional Crossing Contractors Association at a small cost and is readily available (7).

International TT research colloquiums where researchers from all over the world are present facilitate debate on topics considered to be the most importance to the delegates. This information is also accessible on a web page (1,7).

Standard of Technical Information

The technical information is of a particularly high standard.

Relevance of Technical Information

It is anticipated that technical information provided by construction and materials standards can be adapted for South African conditions. This information can be used as a starting point.

Discussion

It is evident from the literature survey that there is a wealth of information on TT available on the Internet and the relevant web sites. However, there is little information on standards per se. Information is very fragmented and no evidence could be found indicating that any of the overseas countries had produced TT standards in a format similar to that of SABS 1200 or envisaged by this project.

CONCLUSIONS & RECOMMENDATIONS

Conclusions

There is ample evidence of TT specifications and standards in overseas countries. However, these are not National documents but published under the auspices of TT societies in association with other bodies and learned societies. This information is not structured and is to be found over a number of web sites. .

ASTM (14) has collected their standards and specifications on pipe materials into a single document. Other in-house specifications, tender specifications and tender documents by contractors on pipe materials and construction methods are also available.

International TT research colloquiums facilitate debates on other topics and broadens the database in this field.

Recommendations

It is recommended that:

- Contact be made with the listed web sites to start the formulation of proposed codes and standards,
- An inventory be made of relevant documentation and publications to be accessed and if necessary purchased.
- Any work on producing standards in South Africa should be done in close liaison with SABS and in particular the Technical Committee (TC 5120.61) for Construction Standards (1200 series).

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7. Http://www.dmoz/.org This web site gives access to 262 sites on Construction and Maintenance as well as 14 ASTM Specifications and Standards on TT. 773 Web sites on all aspects of construction and maintenance are covered and include the following, Academia, Bulletin Boards and Email Lists, Contracting Firms, Equipment Manufacturers, Portal and Directory Sites, Product Manufacturers, Professional Services, Professional Societies, Publications, Sales and Supply Houses, Trade Shows and Seminars. The Directional Crossing Contractors Association, the North American Society and the International Society of Trenchless Technology can also be found under this web site.
8. Http://www.wef.org This web site gives access to a number of TT rehabilitation sites.
9. Http://bn.com This web site gives access to 12 TT publications.
10. Http://www.insituform.com This web site gives access to the operation of a proprietary TT system with all its specifications.
11. Http://pubs.asce.org/WWWsrch.cgi/ This web site gives access to 73 TT publications.
12. Http://www.astt.com.au/notrench.htm This web site gives access to TT guidelines in Australia.
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DISCUSSION DOCUMENT

Developing a Framework for Establishing Appropriate Trenchless Technology Guidelines and Standards in Southern Africa

A contribution to the effective and efficient design, specification, installation, operation, maintenance, and rehabilitation of freshwater supply, wastewater disposal and other buried services

Joint Venture between Technikon Pretoria and Pipeline Installation and Professional Engineering Services (PIPES) cc

Prepared by A Goyns of PIPES cc

1. BACKGROUND

In South Africa, there are hardly any national standards covering trenchless technology. The only document in common use is 1200 LG for pipe jacking. This is hindering the growth of the industry as authorities and consultants are reticent to specify products or techniques for which there are no standards. From the comments made in several articles that have appeared in *No Dig International*, the official publication of the International Society for Trenchless Technology (ISTT), it appears that this problem is not unique to South Africa.

With the need in mind, an academic institution, Technikon Pretoria, and a specialist consultant, Pipeline Installation and Professional Engineering Services (PIPES) cc, have formed a joint venture to establish a framework within which trenchless technology standards can be written. The project is being funded by the Water Research Commission of South Africa, and has been endorsed by SASTT and two of the largest local authorities in South Africa, namely Johannesburg and Pretoria.

Pretoria Technikon is a tertiary school of technology that focuses on the practical application of engineering principles. PIPES is a specialist consultant that focuses on buried pipelines.

2. ABOUT THE TOTAL PROJECT

At present, it is envisaged that this project will take place in three phases, namely:

- Developing the framework, which is a scoping exercise to establish what is available and where there are gaps (the present consultancy).
- Planning the writing of the standards which will establish the amount of work needed to adapt international or local standards and, where necessary, writing new standards (a future consultancy for which funding will need to be found).
- Producing the standards that would be done in a modular form where the design guidelines, product standards and construction standard specifications for a particular trenchless technique would be published as a package. (This would be a major project, as it would eventaully cover all facets of trenchless technology and funding would be sought from the parties who would benefit.)

The aim of the current phase of this project is to produce a framework for establishing a complete set of South African national TT standards with respect to:

- **Guidelines for Designing, Selecting and Specifying TT Installations** would contain more technical information than current European and American Codes, as TT textbooks are not readily available in South Africa and its neighbouring states. Explanations would, therefore, be provided to support the specified formulae and procedures given. However, they would not be written in the style of a textbook. Where necessary, references would be made to source publications and where they can be obtained.
- **Standards for Pipes Used in TT Installations** would include those made of concrete, ductile iron, fibreglass, high density polyethylene (HDPE), steel, uPVC, and vitrified clay.SABS, ISO and ASTM

Standards already exist for most of these pipe materials. Some could be used directly in the TT standards; others would need amending to ensure that they were appropriate.

- **Standards for Materials Used in TT Installations** would include those used for coating, sealing, grouting, point repair, and lining.
- **Standards for Services Used in TT** would include CCTV inspection and defect classification, ground penetrating radar, leak detection, sonar survey, and utility location.
- **Standard Specifications for TT Installations** would cover the full range of site activities, including close-fit lining, cured-in-situ lining, guided boring and directional drilling, impact moling and ramming, localized repair and sealing, micro-tunnelling, on-line replacement, pipe jacking, sliplining, and spray lining.

Specifications for operating specialized TT equipment would be provided by individual equipment suppliers, as would the specification of this equipment.

The future phases will address the issue of producing these standards in modules, one for each particular technique, comprising:

- Guidelines for designing, selecting and specifying
- Standards for pipes, materials and services used
- Standard Specifications for constructing.

In countries such as South Africa and its neighbours, there is a very real need to inform communities and their leaders about the health and environmental hazards associated with high density urban areas that have inadequate or even no water services and the necessity, when providing adequate services, of using sound environmental technologies to prevent pollution from being shifted from one community to another, as well as preserving what little remains of the natural environment.

While the project itself will address the technical aspects of TT standards, the health and environmental benefits to the country derived from TT can be realised only if there is an adequate awareness campaign. Any such campaign would have to be planned on a national basis, focusing on those communities where the need is greatest. Funding for this purpose would have to be sought as a separate, but related, issue to the production of standards, as the message would be social rather than technical.

3. WHAT THE PROJECT ENTAILS

3.1 Preliminary Literature Survey

This would be initiated by making contact in four directions, namely with:

- the International Society for Trenchless Technology (ISTT) of which SASTT is one of ± 20 affiliated members to establish what TT standards have been produced internationally
- SABS to establish what international TT-related standards are in its library and its arrangements with the other standards organisations about adopting their standards for use in southern Africa.

- SASTT members to establish what standards they use or what they can access from international parent companies or partners
- major local authorities and utilities in South Africa to establish what TT standards they have developed.

This will be followed by a web search to establish what can be found on the subject.

Once the standards available from these various sources are recorded, they will be short-listed for detailed evaluation during the document producing project.

3.2 Discussion Document (current document)

Once the preparatory work has been done, the established skeleton would be expanded to incorporate ideas generated at the initial meetings to form a framework within which the standards could be developed. It is important that this should be presented in a format that suits the southern African market needs and can be used as a discussion document. In addition a questionnaire will be prepared so that responses of interviewees can be quantified and consolidated.

3.3 Select Interviews with Potential Users

The discussion document plus questionnaire would be used as a basis for face-to-face or telephonic interviews with key decision-makers at organisations owning, operating or using buried services in Johannesburg/Pretoria area. The purpose of these interviews would be to gauge user response to the project. They would all be conducted by the same member of the WG to ensure consistency.

3.4 Select Interviews with TT Industry

A further ± 20 interviews would be conducted along the same lines, using the same discussion document but adjusted questionnaires, with consultants, TT contractors, TT material suppliers, and TT service providers based in the Johannesburg/Pretoria area who are SASTT members. The purpose of these interviews would be to gauge the market player's response to the project. Here too, interviews with a particular group would be carried out by a single member of the WG.

3.5 Contact with Other Organizations

As all the potential user organizations ultimately fall under the jurisdiction of one or other government department, an audience would be requested with a senior representative of each relevant department to present the case for TT.

3.6 Framework for TT Standards

The information gathered from the literature survey and the interviews together with the discussion document to produce the framework, which would be the end product of this project and serve as the starting point for the future project to produce SA national TT standards.

4. SKELETON OF FRAMEWORK

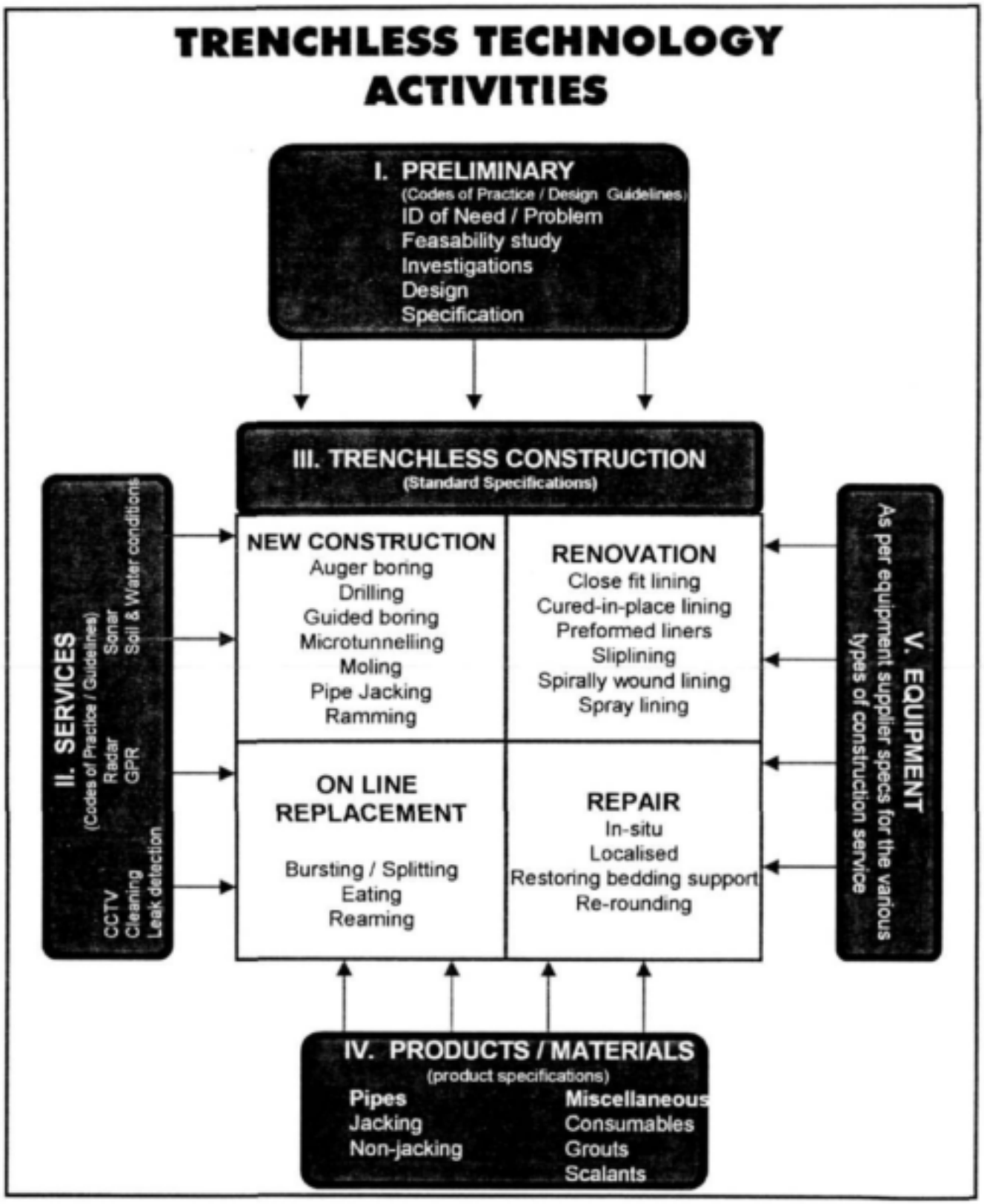
Based on the "Buyers Guide 2001" given in the December 2000 issue of *No Dig International*, the attached diagram has been prepared to show the relationship of various TT activities.

5. DISTRIBUTION

This document has not been distributed as it stands, but was used as the basis for letters written to:

- ISTT : International Society for Trenchless Technology
- ASTT : Australasian Society for Trenchless Technology
- GSTT : German Society for Trenchless Technology
- INDSTT : Indian Society for Trenchless Technology
- NASTT : North American Society for Trenchless Technology
- SSTT : Scandinavian Society for Trenchless Technology
- UKSTT : United Kingdom Society for Trenchless Technology
- Dr J Gumbel : Chairman of European Committee on Rehabilitation

and for the discussions with interviewees.


TRENCHLESS TECHNOLOGY ACTIVITIES
I. PRELIMINARY
(Codes of Practice / Design Guidelines)
ID of Need / Problem
Feasability study
Investigations
Design
Specification
III. TRENCHLESS CONSTRUCTION
(Standard Specifications)
NEW CONSTRUCTION
Auger boring
Drilling
Guided boring
Microtunnelling
Moling
Pipe Jacking
Ramming
RENOVATION
Close fit lining
Cured-in-place lining
Preformed liners
Sliplining
Spirally wound lining
Spray lining
ON LINE REPLACEMENT
Bursting / Splitting
Eating
Reaming
REPAIR
In-situ
Localised
Restoring bedding support
Re-rounding
II. SERVICES
(Codes of Practice / Guidelines)
Radar
Sonar
GPR
Soil & Water conditions
CCTV
Cleaning
Leak detection
V. EQUIPMENT
As per equipment supplier specs for the various types of construction service
IV. PRODUCTS / MATERIALS
(product specifications)
Pipes
Jacking
Non-jacking
Miscellaneous
Consumables
Grouts
Scalants

ORGANISATION:
POSITION:
PERSON:

DATE:

REF: MP SUMMARY

RESPONSE TO QUESTIONAIRES
Before adjustments were made

PLEASE MARK THE APPROPRIATE BLOCKS ☑ AND LEAVE OTHERS BLANK ☐

I. INTERVIEWEE CLASSIFICATION

1. Organisation Type

Local Authority	11
Consultant	13
Contractor	
Supplier	
Other	3

If other, what.....

2. Position Held.

Partner/Director	10
Designer/Engineer	11
Site Agent/Manager	1
Resident Engineer	2
Other	3

If other, what.....

3. Activity

Roads & Stormwater	11
Sewer & Water Supply	20
Electricity	
Telecommunications	2
Other	5

If other, what.....

II. AWARENESS OF TT

4 You know about

TT	27
SASTT	16
ISTT	10
No Dig International	11
Are you a **SASTT** Member	6

III. USE OF TRENCHLESS TECHNOLOGY

5 Frequency

Wherever possible	5
Sometimes	12
Seldom	8
Never	1
When applicable	1

6 Reasons

Economic	17
Avoid social disruption	15
Avoid environmental disruption	14
Other	8

If other, what? .....

IV. TRENCHLESS TECHNIQUES USED

7 New Construction

Auger boring	3
Drilling	5
Guided boring	9
Microtunneling	1
Moling	3
Pipe Jacking	22
Ramming	3

8 On-line replacement

Bursting/Splitting	11
Eating	
Reaming	2

10 Repair

In-Situ	9
Localized	8
Restoring bedding support	2
Re-rounding	1

9 Renovations

Close fit lining	0
Cured-in-place lining	7
Performed liners	1
Sliplining	10
Spirally wound lining	
Spray lining	1
Mortar Lining	6

11 Inspection & Location

CCTV	20
Cleaning	12
GPR	4
Leak detection	11
Sonar	0

12. Other techniques .....1.....

V. DESIGN OF TRENCHLESS INSTALLATIONS

13 This done by.

Yourself	13
Specialist	14
Contractor	8
Not done	0
Others	2

If others, who? .....

14 Following specified

Minimum ID	7
Nominal ID	15
Class	15
Strength	12
Pressure	5
Other	5

If other, what?
.....

15 Product specified

Concrete	20
Clay	1
Fibre Cement	
GRP	1
Polyethylene	15
PVC	4
Steel	5

16 Specifications

SABS	10
OWN	3
SPECIFIC	2

VI. TRENCHLESS TECHNOLOGY STANDARDS

17 Standards you use

National Standards when available	15
Own Standards	9
Project Specific Standards	19
None Used	1
Other	2

If other, which .....

18 Your organisation's views on National Standards

Would use if available		26
Would support writing		15
Would contribute to funding	(1 = maybe ?)	6
Would contribute technically		12
Would be prepared to comment		18

19 Your views about project

Would like further information	17
Would be prepared to contribute technically	11
Would be prepared to comment	18

20 Additional Comments

i.e. What priorities
.....
Received 20
.....
.....
.....

VII. COMMENT BY INTERVIEWER

Questionnaires sent out	**36**
Responses – number	**27**
Responses – percentage	**75**

ORGANISATION: DATE:
POSITION:
PERSON: REF: SASTT SUMMARY

RESPONSE TO QUESTIONNAIRES
Before adiustments were made

PLEASE MARK THE APPROPRIATE BLOCKS ☑ AND LEAVE OTHERS BLANK ☐

I. INTERVIEWEE CLASSIFICATION

1. Organisation Type	
Local Authority	2
Consultant	7
Contractor	13
Supplier	11
Other	1
If other, what.....	

2. Position Held.	
Partner/Director	17
Designer/Engineer	5
Site Agent/Manager	7
Resident Engineer	
Other	5
If other, what.....	

3. Activity	
New Construction	19
On-line replacement	12
Renovations	12
Repairs	10
Inspection & Location	15
If other, what.....	5

II. AWARENESS OF TT

4 Knowledge of TT by	H	M	L	N
Local Authority	2	10	8	14
Consultant	5	15	3	11
Contractor	8	9	5	12
Supplier	3	5	7	19
Other	2	1	4	27

III. USE OF TRENCHLESS TECHNOLOGY

5 TT work is	
Prescribed by client	14
Specified by Consultant	18
Requested by Contractor	3
Motivated by Self	24

6 *Reasons for use*	
Economic	18
Avoid social disruption	26
Avoid environmental disruption	22
Other	4
If other, what?	

IV. TRENCHLESS TECHNIQUES / SERVICES YOU OFFER

7 New Construction	
Auger boring	5
Drilling	7
Guided boring	5
Microtunneling	4
Moling	7
Pipe Jacking	10
Ramming	5
Product Supplier	4

8 On-line replacement	
Bursting/Splitting	8
Eating	
Reaming	

9 Renovations	
Close fit lining	5
Cured-in-place lining	4
Performed liners	4
Sliplining	10
Spirally wound lining	1
Spray lining	1
Mortar lining	2

10 Repair	
In-Situ	7
Localized	3
Restoring bedding support	2
Re-rounding	2

11 Inspection & Location	
CCTV	12
Cleaning	6
GPR	5
Leak detection	4
Sonar	0
Cable & Pipe detection	1

12. **Other techniques** .....3.....

V. DESIGN OF TRENCHLESS INSTALLATIONS

13 This done by.

Yourself	21
Specialist	10
Contractor	6
Not done	0
Others	7

If others, who? .....

14 Following specified

Minimum ID	20
Nominal ID	15
Class	18
Strength	16
Pressure	14
Other	5

If other, what?
.....

15 Product specified

Concrete	19
Clay	8
Fibre Cement	2
GRP	6
Polyethylene	17
PVC	7
Steel	11

16 Specifications

SABS	5
OWN	3
ISO	1
OTHER	6

VI. TRENCHLESS TECHNOLOGY STANDARDS

17 Standards you recommend

National Standards when available	24
Own Standards	12
Project Specific Standards	18
None Used	1
Other	4

If other, which .....

18 Your organisation's views on National Standards

Would recommend if available	27
Would support writing	10
Would contribute to funding (Maybe = 2)	3
Would contribute technically	15
Would be prepared to comment	25

19 Your views about project

Would like further information	19
Would be prepared to contribute technically	13
Would be prepared to comment	19

20 Additional Comment

14 Received

.....

.....

.....

.....

VII. COMMENT BY INTERVIEWER

Questionnaires sent out	**40**
Responses – number	**34**
Responses – percentage	**85**

APPENDIX B4 : Details of Marketplace Interviewees

No.	ORGANISATION	PERSON	CONTACT NO.
1	Africon (Pretoria)	Mr J Potgieter	(012) 427-2269
2	Africon (Pretoria)	Mr B Wheeler	(012) 427-2116
3	ARQ	Mr D Cameron-Ellis	(012) 348-6668
4	Asch Consulting	Mr B Erlangsen	(021) 419-9022
5	Benoni Municipality	Ms T Korsias	(011) 741-6261
6	Bigen Africa (Pretoria)	Mr M Pienaar	(012) 803-7444
7	BKS (Pretoria)	Mr R Erasmus	(012) 421-3500
8	BKS (Pretoria)	Mr A Kruger	(012) 421-3500
9	Boksburg Municipality	Mr S Herman	(011) 820-4292
10	Cape Metro Council Roads	Mr C Atkins	(021) 418-6830
11	Cape Metro Council : Wastewater Conveyance	Mr R Mitchell	(021) 487-2735
12	Cape Metro Council	Mr W Olieslager	(021) 487-2911
13	Cape Town Administration	Mr N Ireland	(021) 400-3291
14	Centurion Town Council	Mr LL Lotter	(012) 671-7433
15	Corrosion Control Centre	Mr C Havemann	(012) 664-1551
16	Durban Metro : Water	Mr C Davies	(031) 302-4656
17	ERWAT	Mr L Naudé	(011) 929-7019
18	ESKOM	Mr B Clements	(011) 800-2185
19	Germiston Municipality	Mr H Marx	(011) 871-7911
20	GVM (Pretoria)	Mr G van Heerden	(012) 549-0422
21	J&G (Sandton)	Mr G Lourens	(011) 807-0660
22	Johannesburg Roads Agency	Mr A Agaienz	(011) 787-9309
23	Kempton Park Municipality	Mr H Gouws	(011) 921-2262
24	Knight Piesold (Cape Town)	Mr R Hoogwerf	(021) 421-2508
25	Knight Piesold (Cape Town)	Mr W van der Poll	(021) 421-2507
26	Protocon (Spoornet)	Mr H de Wet	(011) 773-7977
27	Rand Water	Mr A Tonks	(011) 682-0257
28	SA National Roads Agency Ltd	Mr E Kruger	(012) 426-6038
29	SASTECH (Sasolburg)	Mr D van Rensburg	(016) 960-2465
30	Soweto Water	Mr D Fourie	(011) 938-1735
31	Tshwane Metro Council	Mr J Wessels	(012) 308-7638
32	Waites Meiring & Barnard	Mr A van Niekerk	(011) 422-4823
33	Wedge Projects	Mr J Vermeulen	(012) 346-5580
34	ZMCK (Swaziland)	Mr C Rodda	(09268) 416-1461

APPENDIX B5 : Details of SASTT Corporate Member Interviewees

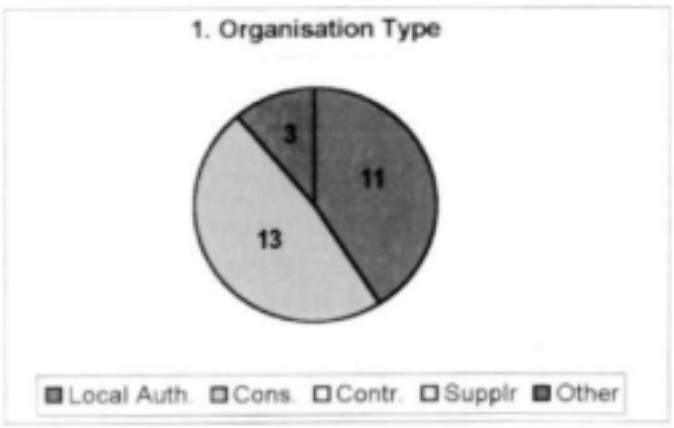
No.	COMPANY	REPRESENTATIVE	CONTACT No.
1	CSIR - Boutek	Joop van Wamelen	(012) 841-4034
2	Directional Drilling Services cc	Mike Kotsiovos	(011) 425-0651
3	Esor (Pty) Ltd	Bernie Krone	(011) 822-3906
4	Fairbrother Geotechnical Engineering	Ian Fairbrother	(021) 715-5470
5	Fraser Fyfe	Hennie Breedt	(011) 827-3517
6	Fyfe-Vitro	Herman Hoffman	(016) 988-1130
7	Geo Franki	Chris Wagener	(011) 887-2700
8	Greater Johannesburg Metropolitan Council	Mike Hall	(011) 334-5595
9	Insitu-Pipelines cc	Pius Walsh	(011) 786-8099
10	Jacked Pipelines (Pty) Ltd	Chris Wrench	(011) 973-1828
11	Johannesburg Water (Pty) Ltd	Rodney Nay	(011) 303-8674
12	Main Industries	Ian Venter	(012) 541-1080
13	Per Aarsleff SA (Pty) Ltd	Willem Geyer	(011) 887-8617
14	Peter Oates Pipelining (Pty) Ltd	Thor Bovim	(021) 905-3957
15	Pipeline Eye	Trevor Quigley	(011) 485-3262
16	Potgieter Hattingh & Raspi	Alf Raspi	(011) 792-8513
17	Precision Directional Boring cc	Denis McCarthy	(012) 258-0335
18	Radio Detection	Paul Tuson	(011) 452-0758
19	Reef Trenchless Technology (Pty) Ltd	Chris Ehlers	(011) 828-2397
20	Rocla Ltd	Hennie Cronjé	(011) 472-1771
21	SAMAT Mining (Pty) Ltd : Geotechnical Division	Brett Pollington	(011) 974-2051
22	Trenchless Technologies cc (Honeywood)	Sam Efrat	(021) 782-6460/1

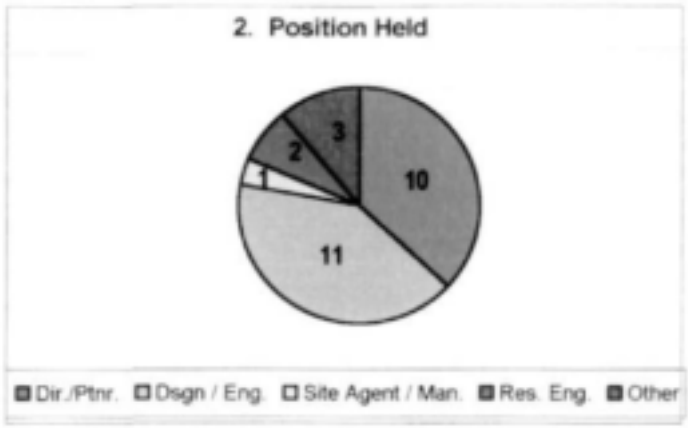
APPENDIX B6 : Details of SASTT Individual Member Interviewees

No.	MEMBER	COMPANY	CONTACT No.
1	WJH Bekker	SNA Civil & Development Engineers	(012) 842-0013
2	Craig N Burnie	Wirtgen South Africa (Pty) Ltd	(011) 452-1838
3	W de Vallier	De Leuw Cather (North)	(011) 403-3731
4	Glen Derman	PICS	(012) 660-0886
5	JL Frey	Tuboseal cc	(021) 852-3081
6	JP Groenewald	Africon	(021) 421-6527
7	Falk Hedrich	Engineered Linings	(011) 974-1397
8	Paul J le Roux	Keeve Steyn Inc	(011) 236-3300
9	GM Nunn	Octopus Electronics	(021) 683-3990
10	Malani Padayachee	Malani Padayachee & Ass. (Pty) Ltd	(011) 789-5417
11	Graham Simpson	VKE Engineers	(031) 28-8143
12	Gordon R Stewart	Liebenberg & Stander Western Cape (Pty) Ltd	(021) 421-2430

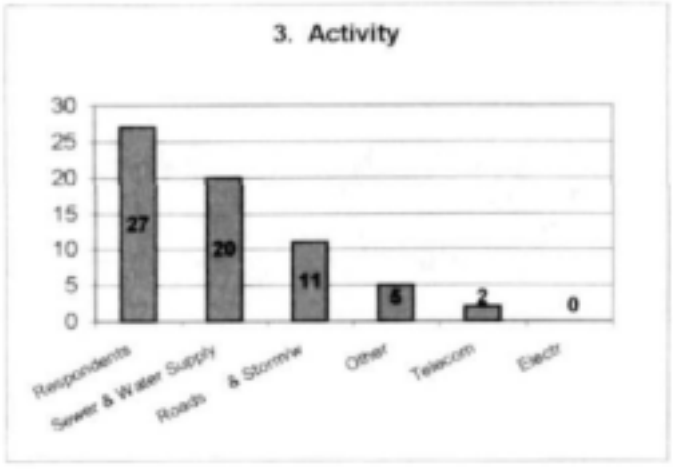
APPENDIX B7 : Evaluation of Questionnaires from Marketplace

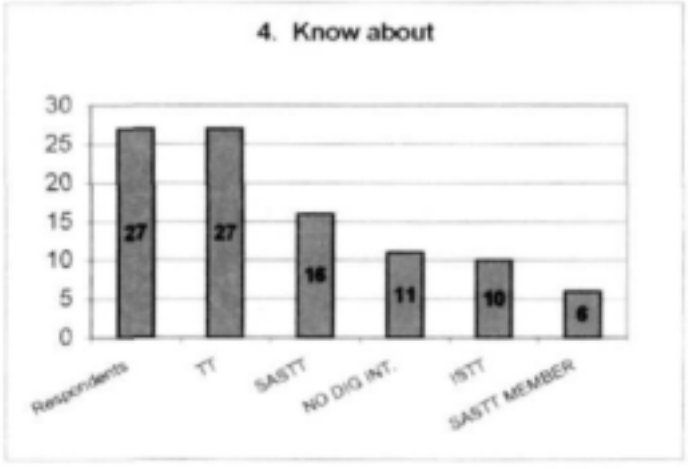
I INTERVIEWEE CLASSIFICATION



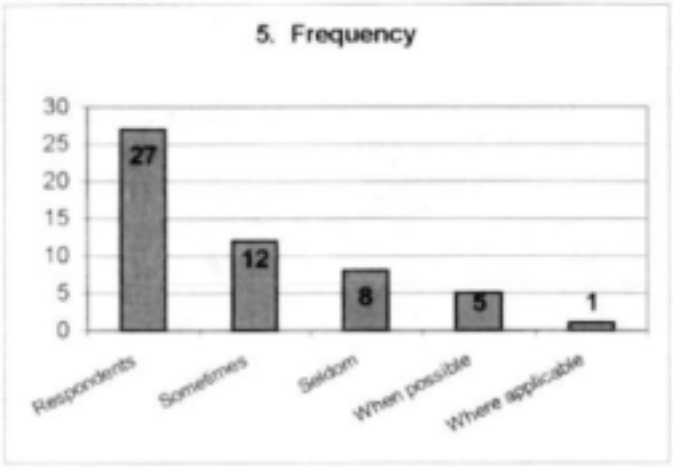


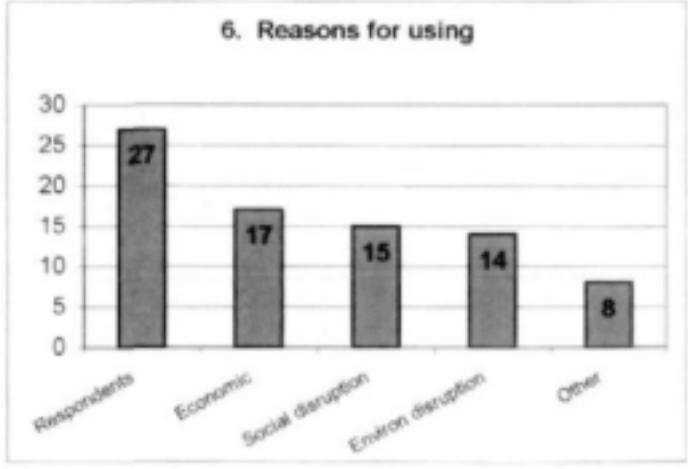
II AWARENESS



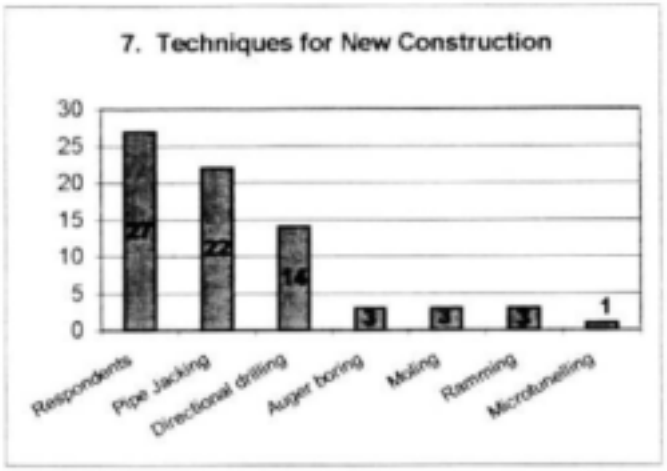


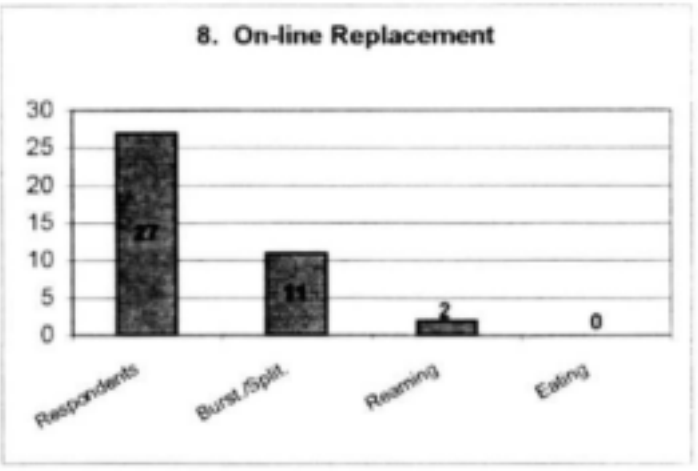
III USE OF TT

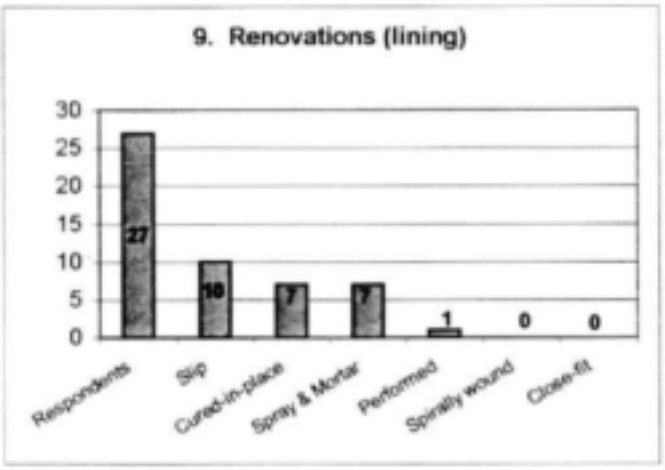


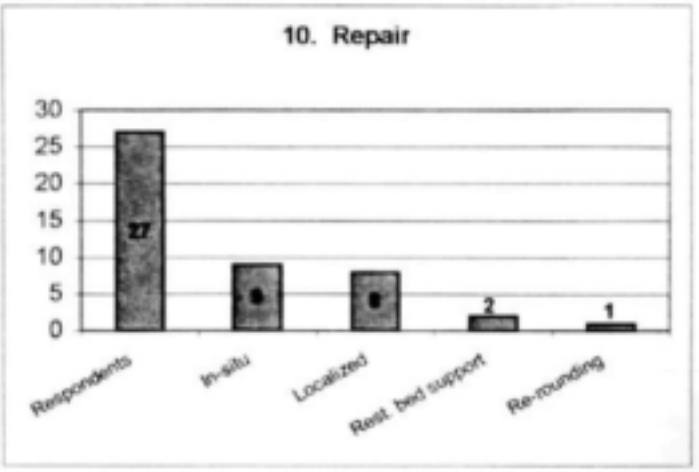


IV TRENCHLESS TECHNIQUES USED

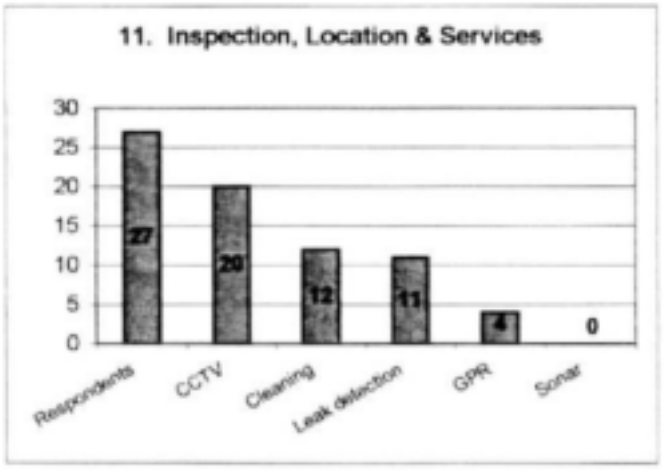




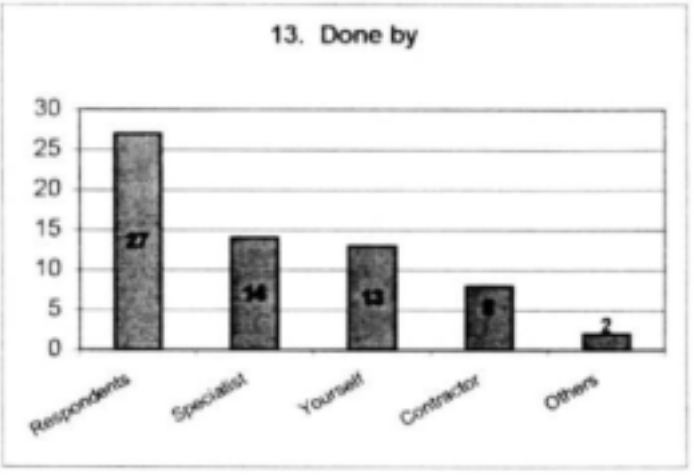




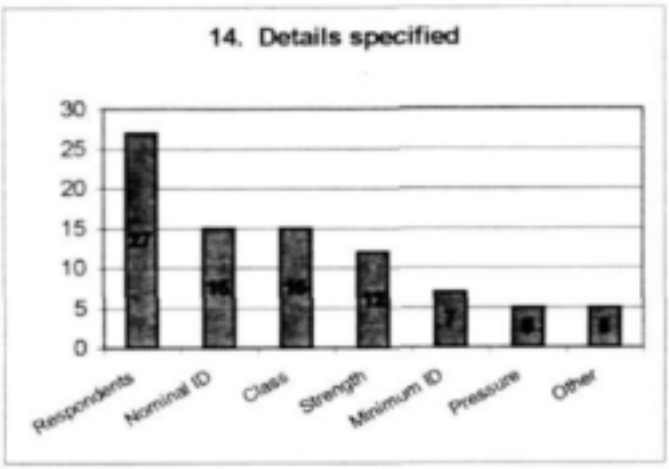
V DESIGN OF TRENCHLESS INSTALLATIONS

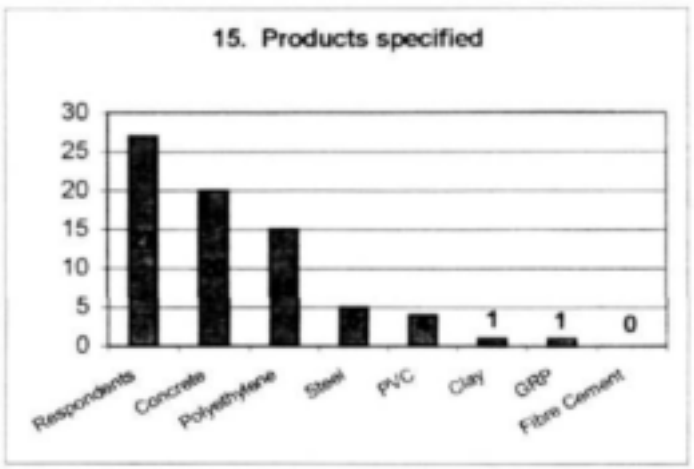


12. Other Techniques used
One other used, namely Joint sealing

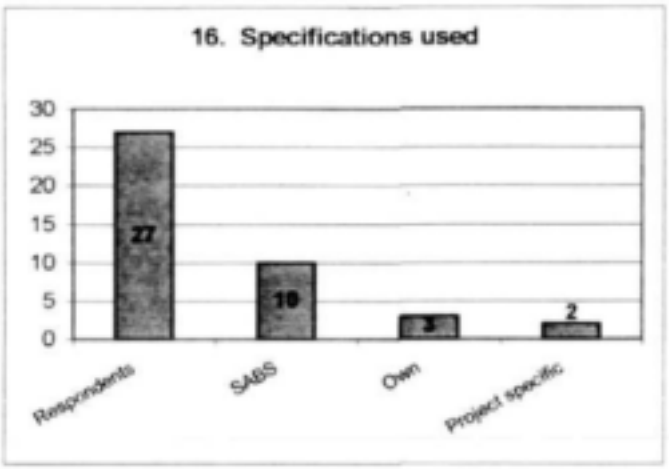


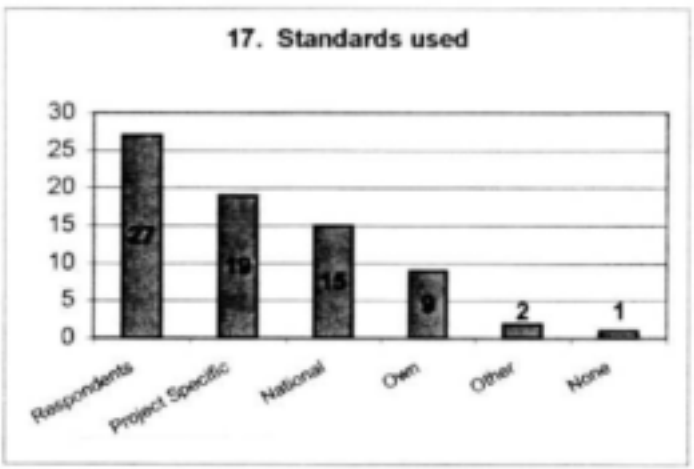
V DESIGN OF TRENCHLESS INSTALLATIONS (Continued)

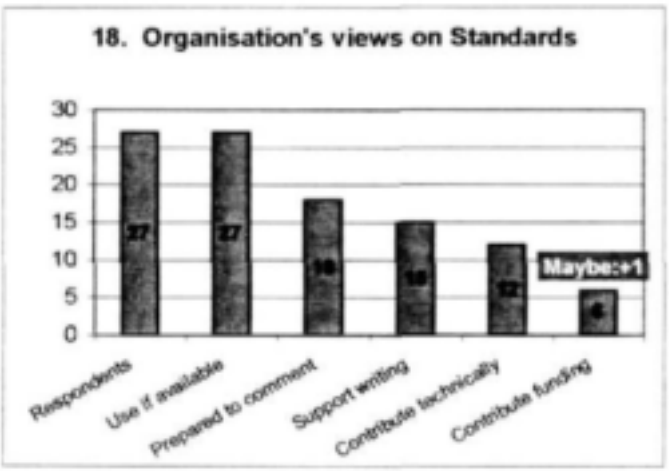


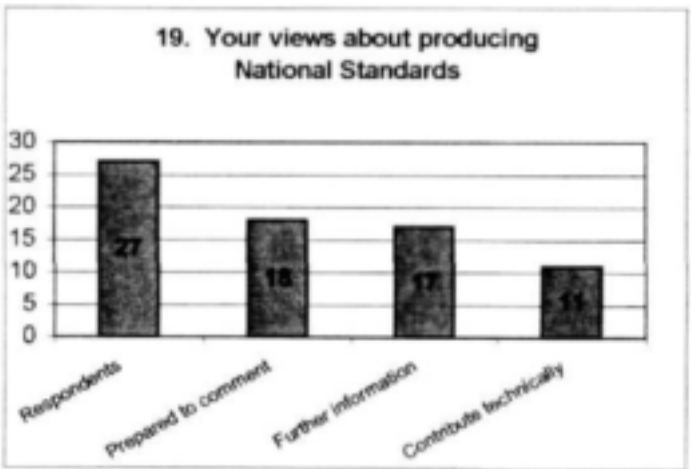


VI TRENCHLESS TECHNOLOGY STANDARDS









20. Additional Comment

This was received from 20 of the respondents.

APPENDIX B8 : Questionnaires from Marketplace - Additional Comments

i. We don't use TT enough.

ii. We'd like to encourage other services to use the TT approach to avoid cutting into our roads.

iii. Local authorities should support writing and contribute both technically and financially to producing national standards. A directive in this regard is needed.

iv. It may be possible to get CMIP funds to develop some of the standard specifications.

v. Priorities (for the writing of standards) are:
   - Trenchless rehabilitation of existing pipes
   - Trenchless replacement
   - Pipe-cleaning and CCTV

vi. We are generally not prescriptive to consulting engineers as they take full technical responsibility. We generally look at economy from a construction and user point of view. Our consultants usually use the "Colto" specifications.

vii. From our experience as a utility, TT is very important and part of urban engineering. A need for a proper specification is definitely needed to assist clients.

viii. The sooner such a project commences the better. Many experienced engineers have retired and their comments from a practical viewpoint, while still possible, will be of great assistance.

ix. A national specification is a priority. We have used directional drilling on a limited basis only due to the lack of local expertise and lack of specifications.

x. There is a glaring gap in the appropriate specifications to be used. This should be given priority.

xi. Companies performing TT should be grouped according to method used and their company profiles should be made available to organisations to make use of their services.

xii. We will be prepared to assist to the level of expertise and involvement which are possible at the time.

xiii. The Department of Civil Engineering at our municipality has never used TT, but is currently investigating TT as part of its "Way-Leave Policy" for construction in road reserves.

xiv. Designer guidelines are a priority.

xv. Priorities include:
   - Pipe jacking
   - Pipe-cracking/sliplining
   - Guided boring

xvi. Standards are long overdue and would be appreciated.

xvii. Priorities for standards are:
   - Gravity systems
   - Pipe/joint systems
   - Get working documents out

APPENDIX B8 : Questionnaires from Marketplace - Additional Comments

xviii. Would like to see measurement and payment included with specifications.

xix. Separate SABS standard for all TT.

xx. Priorities for standards are that jacked pipes should not be used as the conveyance pipe unless oversized and re-inverted (an invert cast in after installation). This is specifically so that tolerances can be met.

xxi. Would like measurement and payment in same document.

xxii. Higher standards will add credibility to TT.

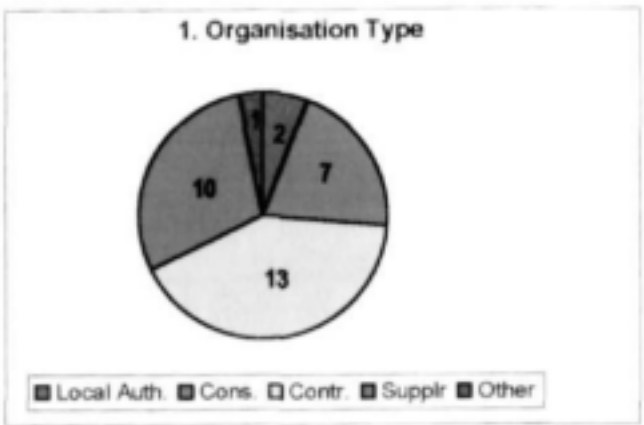
xxiii. I foresee an increasing need for the use of TT – both for general remediation as well as to avoid extreme traffic and environmental disruptions. Please contact our Metropolitan transport directorate.

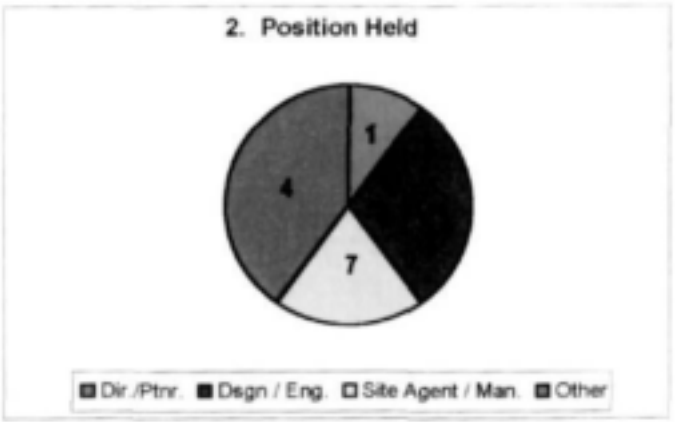
xxiv. Definite need for rehabilitation by means of TT.

xxv. Keep updating what is on the market from a technical aspect.

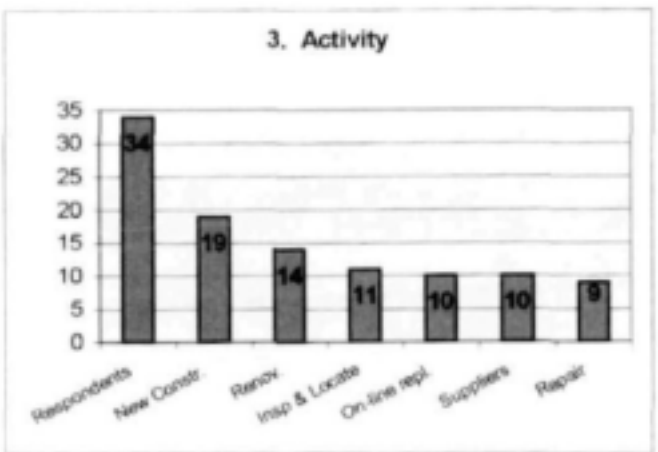
APPENDIX B9 : Evaluation of Questionnaires from SASTT Members

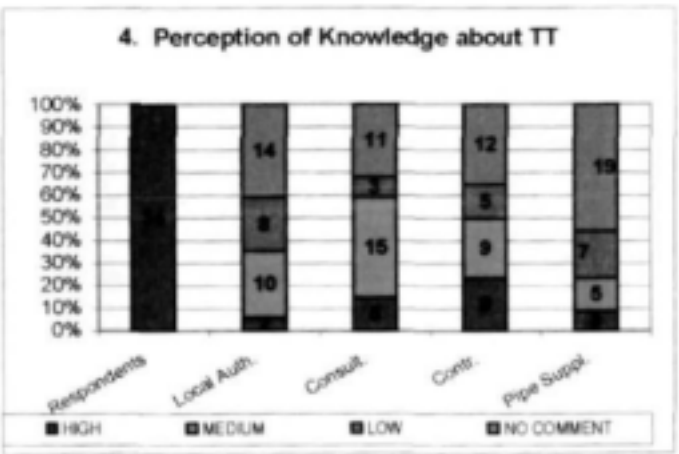
I INTERVIEWEE CLASSIFICATION



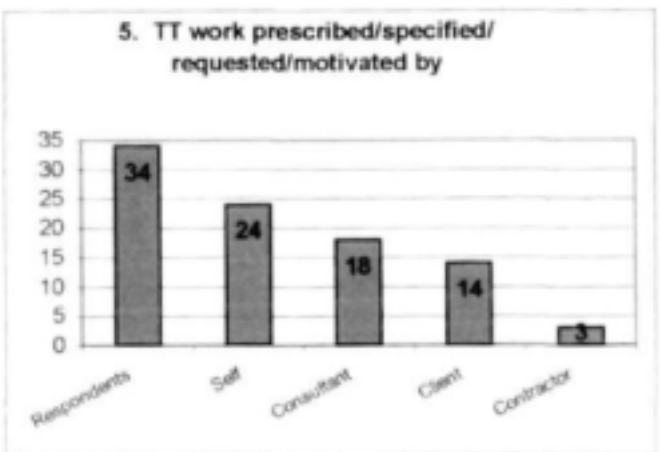


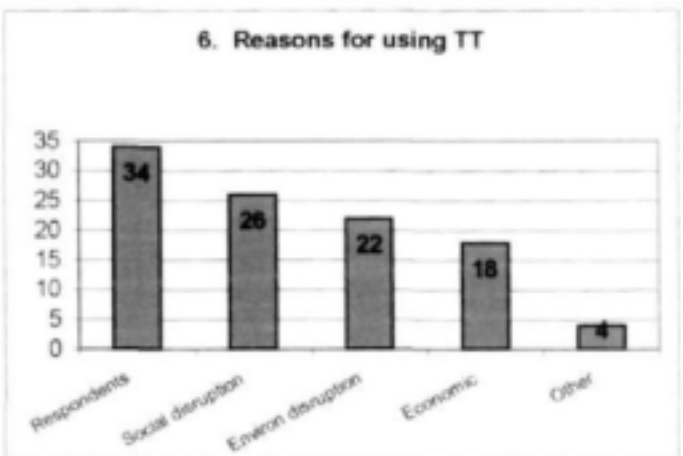
II AWARENESS





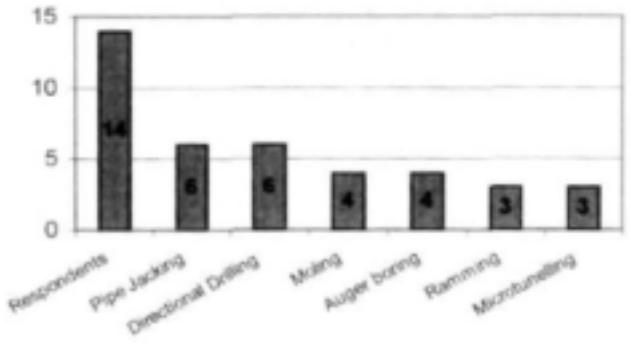
III USE OF TT





IV TRENCHLESS TECHNIQUES/SERVICES YOU OFFER

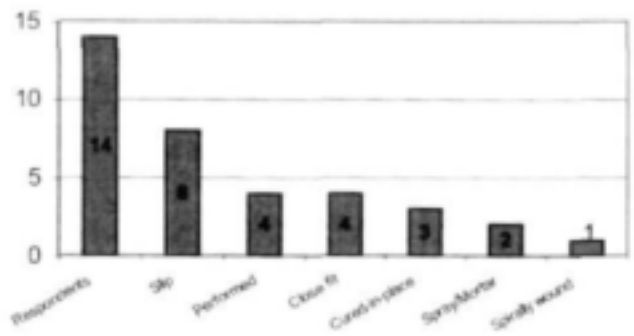
7. New Construction



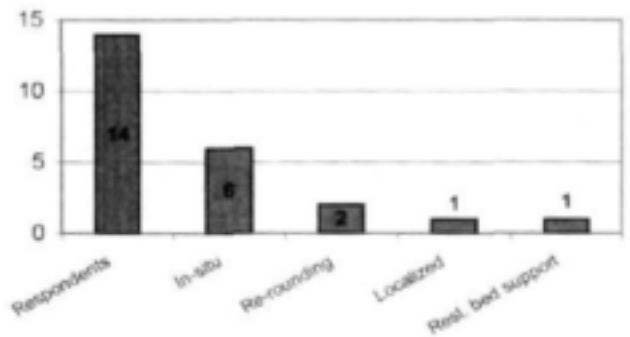
8. On-line Replacement

Only one technique used, namely pipe bursting/cracking/splitting. There were five who offered this

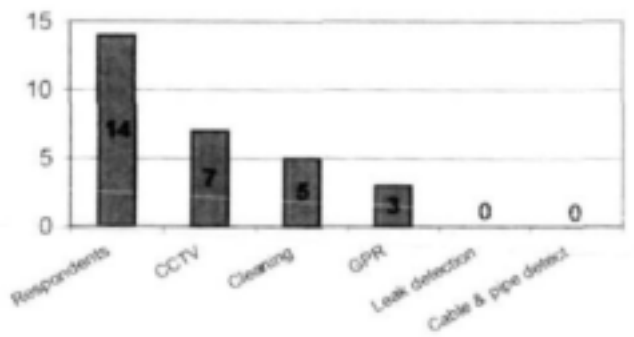
9 . Renovation (lining)



10. Repair



11. Inspection, Location & Services

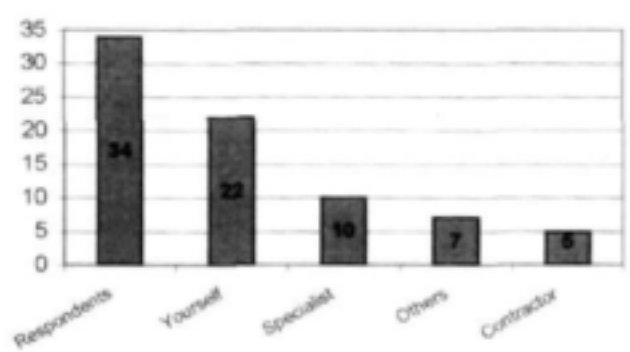


12 Other techniques used

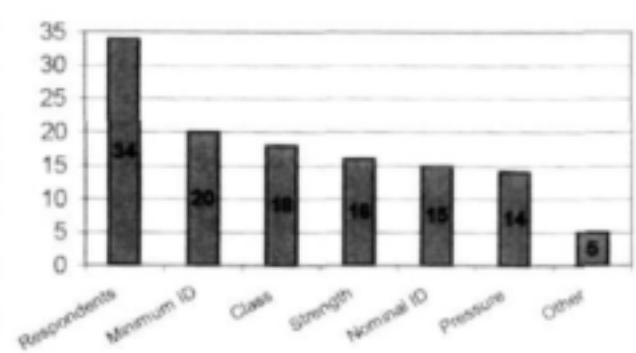
Three, namely tunnelling, swage lining and cable & pipe detection

V DESIGN OF TRENCHLESS INSTALLATIONS

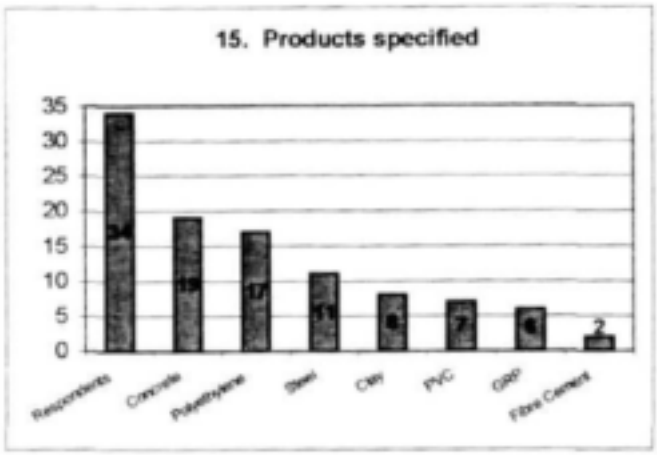
13. Design done by

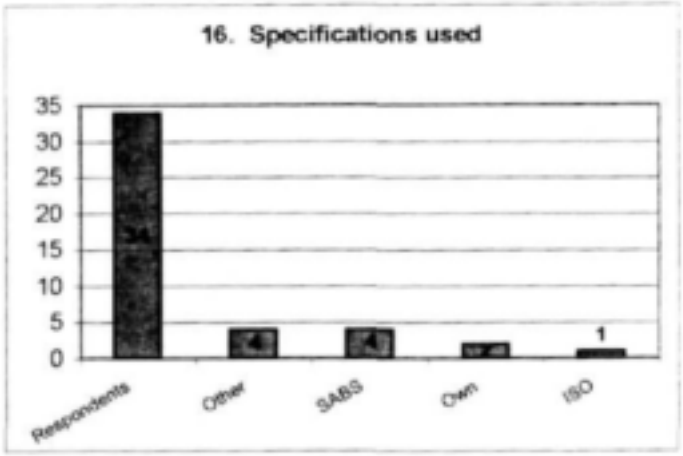


14. Details specified

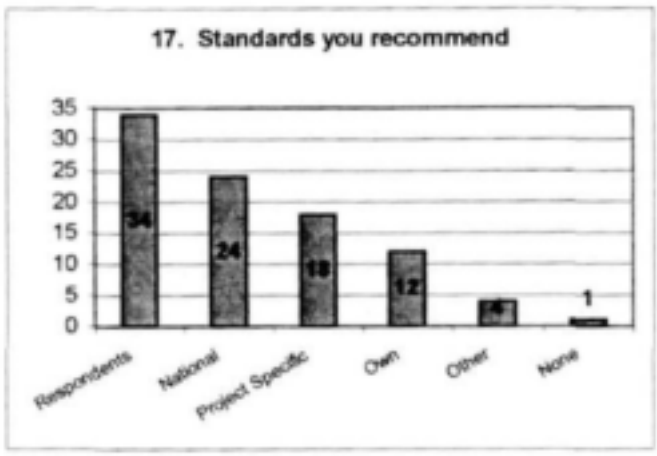


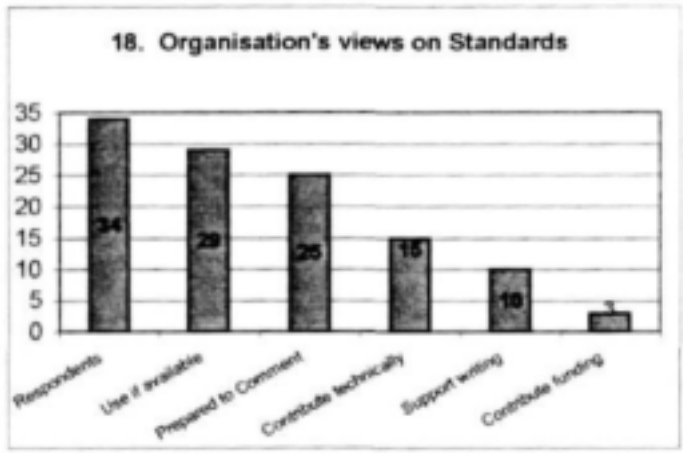
APPENDIX B9 : Evaluation of Questionnaires from SASTT Members

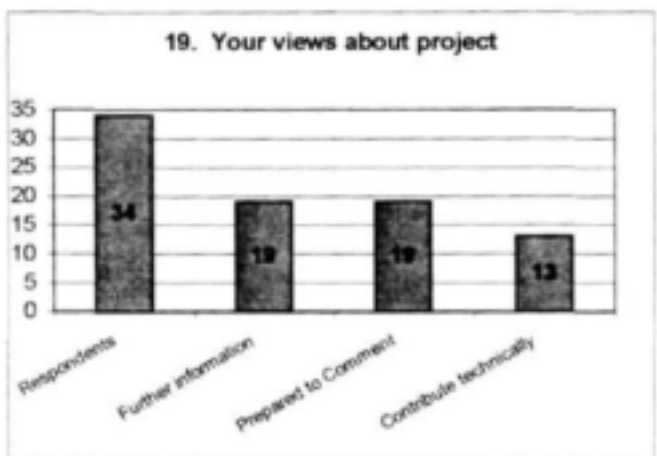




VI TRENCHLESS TECHNOLOGY STANDARDS







20. Additional Comment

This was received from 14 of the respondents and is given in Appendix B10.

APPENDIX B10 : Questionnaires from SASTT Members - Additional Comment

i. Our interest lies mainly in encouraging consultants and clients to use the SABS 1200 LG and appropriate meaningful project specifications.

ii. Lots of interest from various people to the letter from SASTT. People want to know more about the concept and what is available.

iii. Would like to help where required.

iv. Would be an advantage to have guidelines, relating to economic benefits (of TT) to prepare quick calculations to present to clients at planning stage.

v. Priorities are:

- Soils information
- Improved concrete pipe design for pipe jacking

vi. Importance of specifying what is required of camera survey

vii. Priorities are:

- Standard installation procedures and (product) specifications
- Too many unqualified contractors trying to do this type of work

viii. Priorities are:

- To get message to consulting fraternity that TT is specialist work (especially jacking) and awarding purely on price is going to directly cause a major problem.
- Standard specifications/BoQs etc are needed for all TT work – even if this information is available, it is hopeless if contracts are going to be awarded purely on price to contractors with no track record, mickey-mouse equipment, inexperienced supervision, etc.

ix. Have really only been involved in a few auger bores, ram bores, and pipe jacks, but will continue to promote other forms of TT.

x. Small diameter boring specification and measurement needed.

xi. Concrete jacking pipe standards need to be upgraded with particular emphasis on jacking as opposed to load-carrying stresses

xii. The sooner the better. It is of high importance that this happens – for company and country.

xiii. A local standard is needed fast.

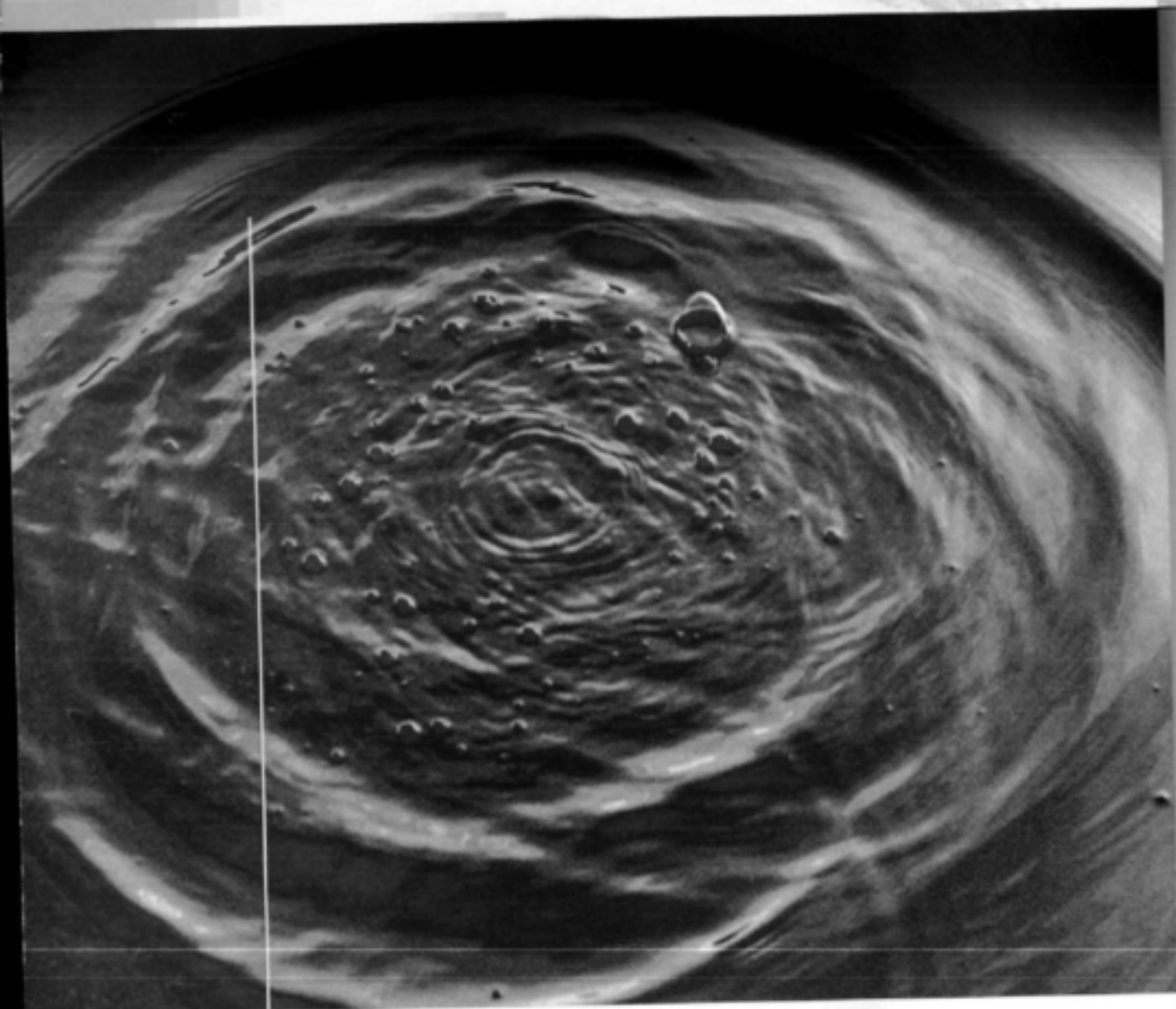
xiv. Do not have much opportunity for TT in current position.

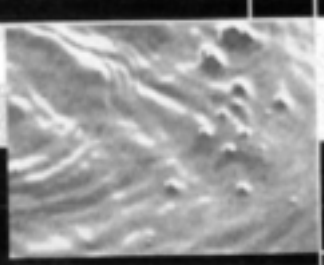
xv. I hope that my participation in a programme is of assistance to you (SASTT).

xvi. I should be happy to review and comment on any standards regards to:

- Moling
- Pipe ramming
- Direction drilling
- Sliplining with HDPE
- Pipe cracking with HDPE.

xvii. Most of information/standards (on installation) available internationally and many in industry (in SA know about them). Why reinvent the wheel?





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