



CONFRONTING RISK FOR UNDERGROUND PROJECTS

By: Dr. Gary S. Brierley



Helping geoprofessionals

MAXIMIZE

their importance and value to the marketplace by

CONFRONTING RISK!

RISK EXPOSURE FOR UNDERGROUND PROJECTS

- ✓ Risk is defined as exposure to injury or loss.
- ✓ Confront is defined as “coming face to face with a problem, often in conflict.”
- ✓ Whose risk are we trying to confront?



- ✓ In order for geotechnical engineers to be successful, they must optimize the subsurface outcome for their client.
- ✓ For most geotechnical assignments the client is an owner, an engineer, or an architect for whom the Geotech provides design criteria.
- ✓ For projects utilizing a GBR the client is a contractor (via the contract document) for whom the Geotech provides construction “criteria.”

TUNNELS ARE DIFFERENT THAN ABOVE-GROUND STRUCTURES

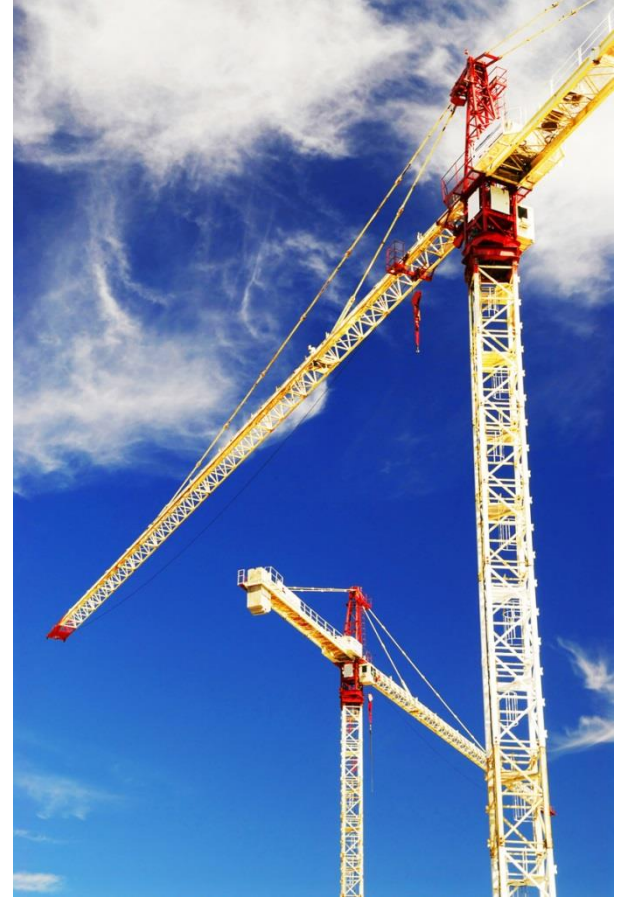


- ✓ Entirely within the ground.
- ✓ “Differing Site Conditions.”
- ✓ The ground can be changed.
- ✓ Serial construction schedule.



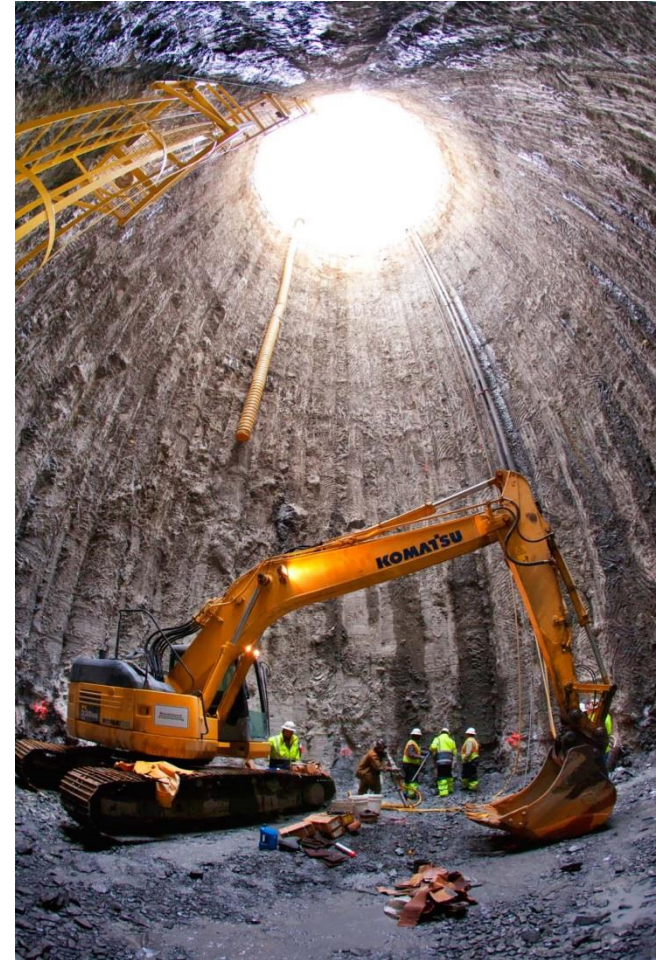
TUNNELS ARE DIFFERENT THAN ABOVE-GROUND STRUCTURES

- ✓ Work from the inside/out.
- ✓ The ground requires temporary support.
- ✓ Lots of third party impacts.
- ✓ Land not owned by the project.



IN ORDER TO BUILD A TUNNEL, YOU MUST:

- ✓ **Excavate** the ground.
- ✓ **Control** the ground during the process of excavation.
- ✓ **Support** the ground as the tunnel is advanced.
- ✓ **Install** the final lining.

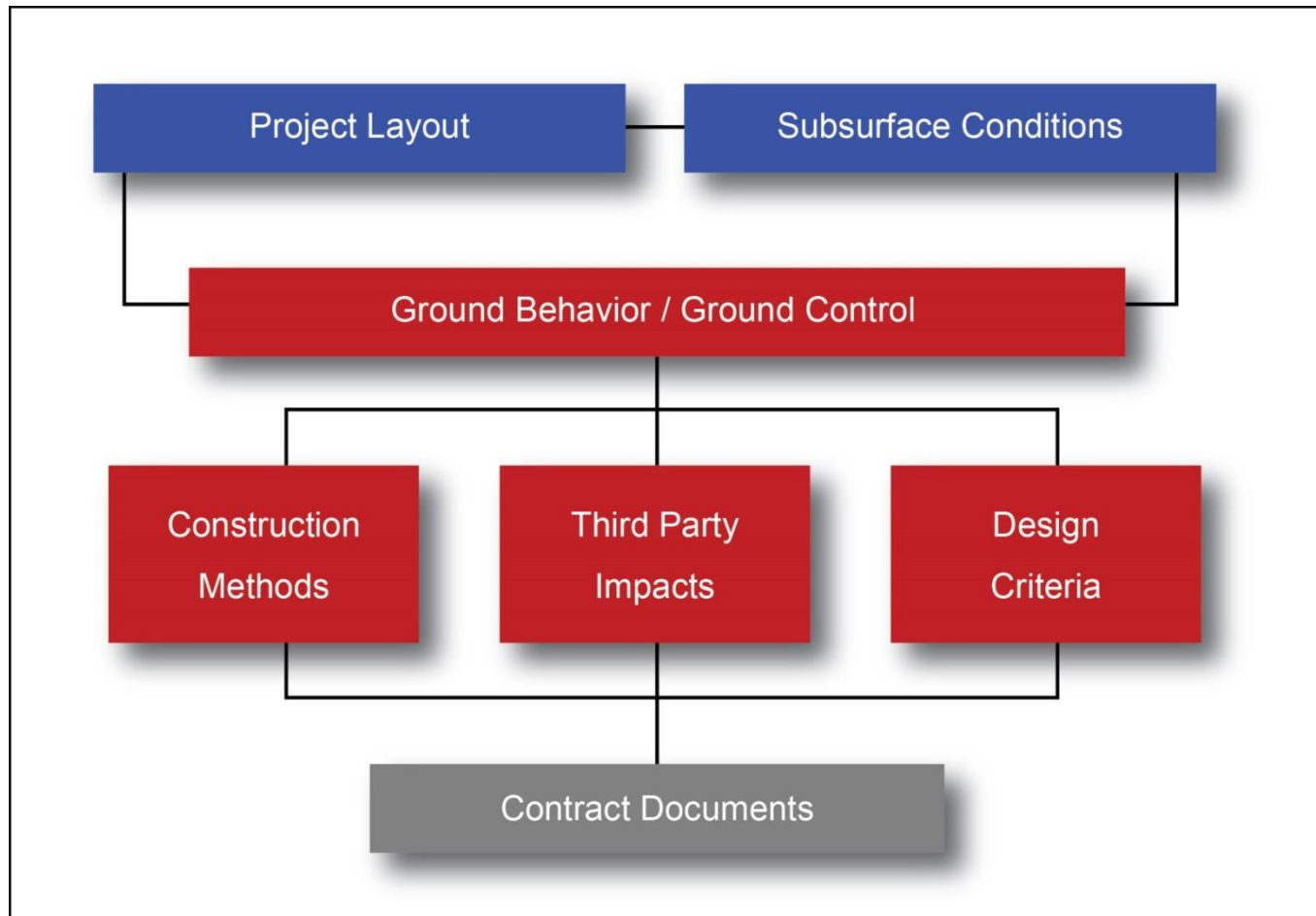


WHAT THE OWNER WANTS IS THE FINAL LINING!

**The Owner views excavation,
control and support as necessary evils!**

**Unfortunately, excavation,
control, and support represent
2/3's of the cost of a tunnel!**

EVALUATING TUNNELING ISSUES



SCOPE OF WORK

- ✓ Subsurface Conditions
- ✓ Project Layout
- ✓ Temporary and Final Design
- ✓ Means and Methods
- ✓ Third Party Impacts
- ✓ Tunneling Technology
- ✓ Ground Improvement



RISK MANAGEMENT



- ✓ The Geotech
- ✓ The Designer
- ✓ The Contractor
- ✓ The Owner
- ✓ Third Parties
- ✓ Insurers, etc.

RISK MANAGEMENT BY THE GEOTECH

- ✓ Identify (Subsurface Investigation)
- ✓ Avoid
- ✓ Minimize
- ✓ Control
- ✓ Assign



STRATEGY VS LOGISTICS



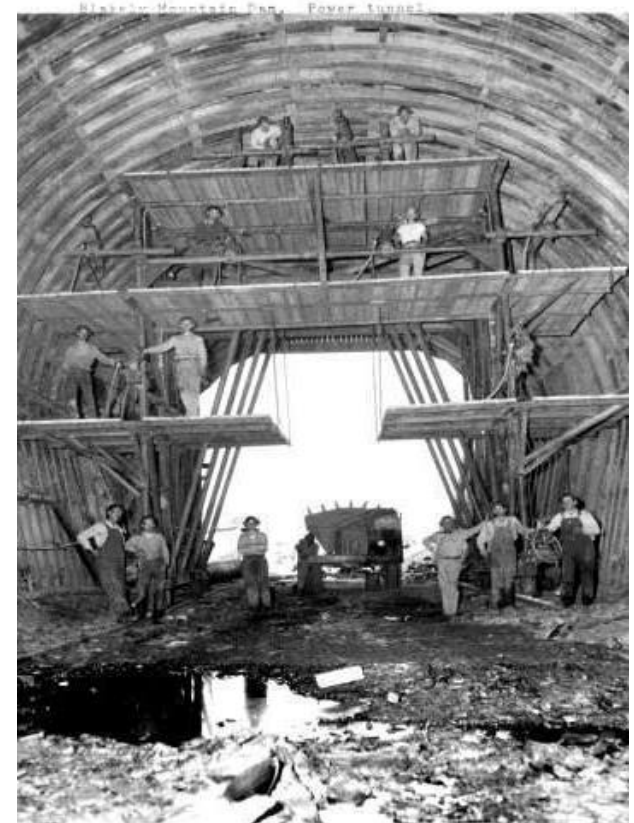
SUBSURFACE CONDITIONS

- ✓ Obtain factual information about soil, rock, and groundwater.
- ✓ Comprehensive and Reliable.
- ✓ Do you know enough about the ground to produce a satisfactory contract document?



DIFFERING SITE CONDITIONS

- ✓ The contract document is the single-most important output of the design process.
- ✓ A contract should clearly define each party's obligations.
- ✓ The DSC clause throws a wrench into this concept.
- ✓ High level of concern for a project that is entirely within the ground.



THE CONTRACT DOCUMENT

The **Geotechnical Data Report** and the **Geotechnical Baseline Report** are both very important parts of the **Contract Document** for an underground (tunneling) project.

THIRD PARTY IMPACTS

- ✓ There can be hundreds of third party impacts associated with an urban tunneling project.
- ✓ Almost never any written agreement with these parties.
- ✓ If anything goes wrong, anyone/everyone associated with the project could become a target.



TEMPORARY AND PERMANENT DESIGN

- ✓ Most of the risk and the cost of tunneling is associated with the “temporary” facilities.
- ✓ How much will it cost and how long will it take to create a safe and stable opening in the existing ground condition.
- ✓ Design of the final facility can be problematic, but is usually rather straightforward.

JOB SITE SAFETY

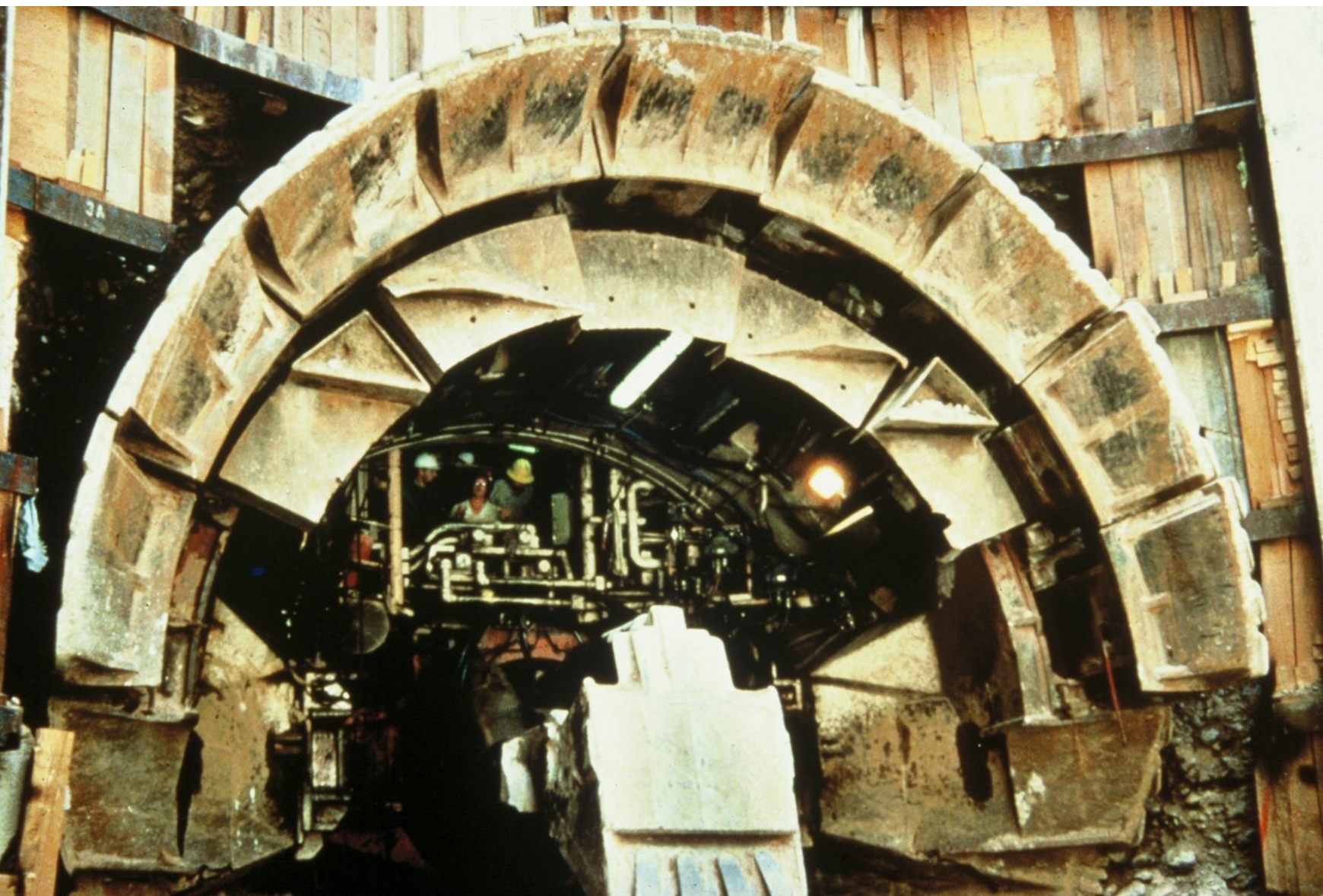
- ✓ Despite all of the above you must insulate yourself from responsibility for on-site safety
- ✓ Only enter a site as a guest of either the Owner or the Contractor and follow their directions without reservation.
- ✓ You may still become responsible for public safety via third parties.

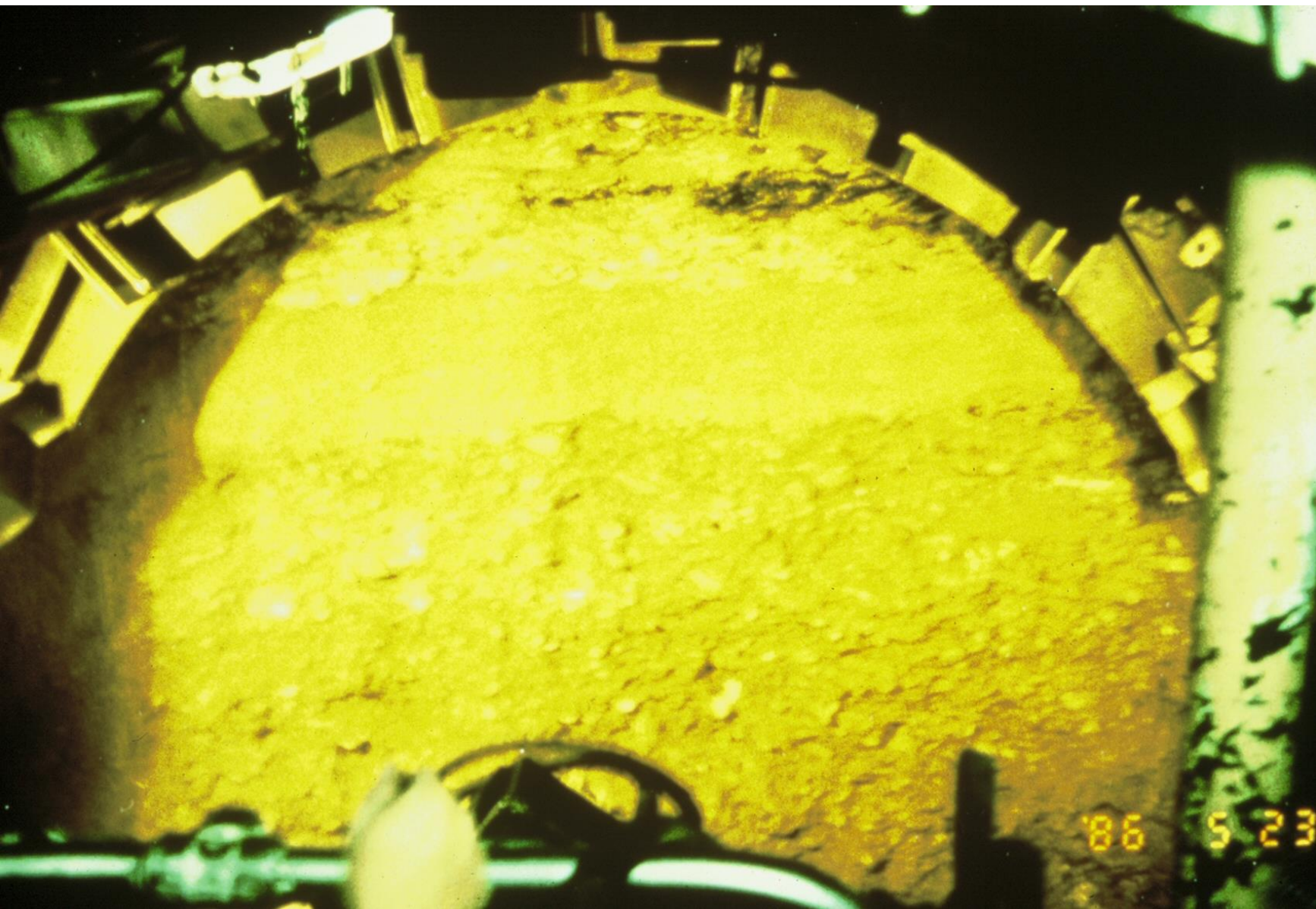


JOB SITE SAFETY

20

- ✓ *Insofar as job site safety is concerned, the Company is responsible only for the health and safety of its own employees. Nothing herein shall be construed to relieve Client or any other consultant or contractor from its responsibility for maintaining a safe job site. The Company shall not advise on, issue directions regarding, or assume control over safety conditions and programs for others at the job site: Neither the professional activities of the Company, nor the presence of this Company or its employees, shall be construed to imply that Company controls the operations of others or has any responsibility for job site safety.*
- ✓ *The Company shall not be required to provide a Competent Person to be on site as defined by OSHA 29 CFR 1926.32 (f)*















SOUTH AUSTIN REGIONAL WASTEWATER TREATMENT PLANT

Presented By:

**Kevin
Koeller, P.E.**

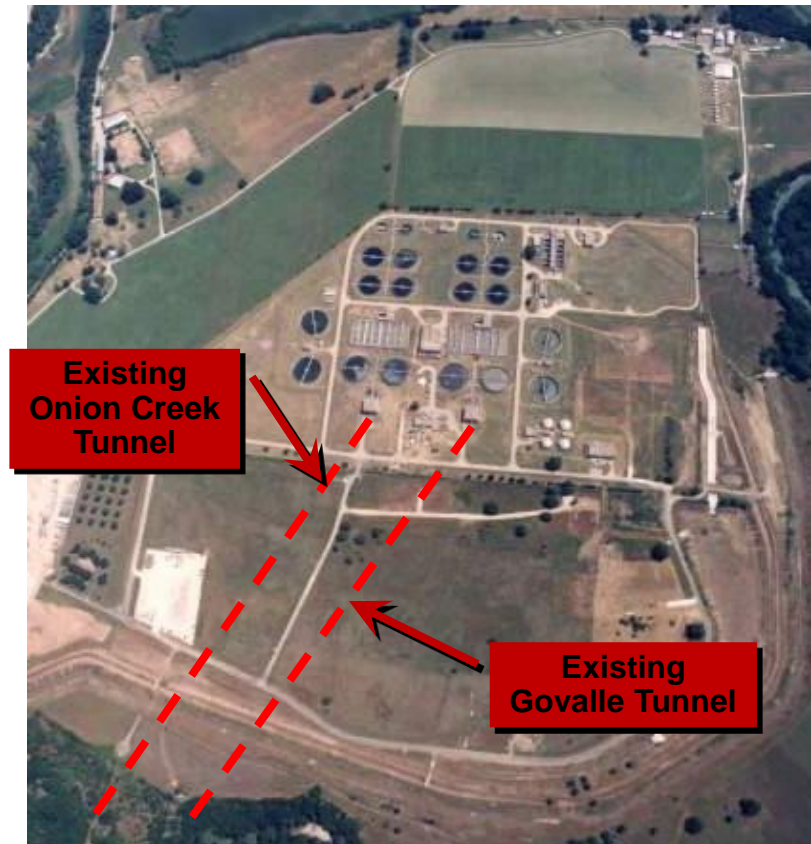
**Gary Brierley,
P.E.**

Tunneling Through Backfill and Lift Station Walls Without Disturbing Plant Operations



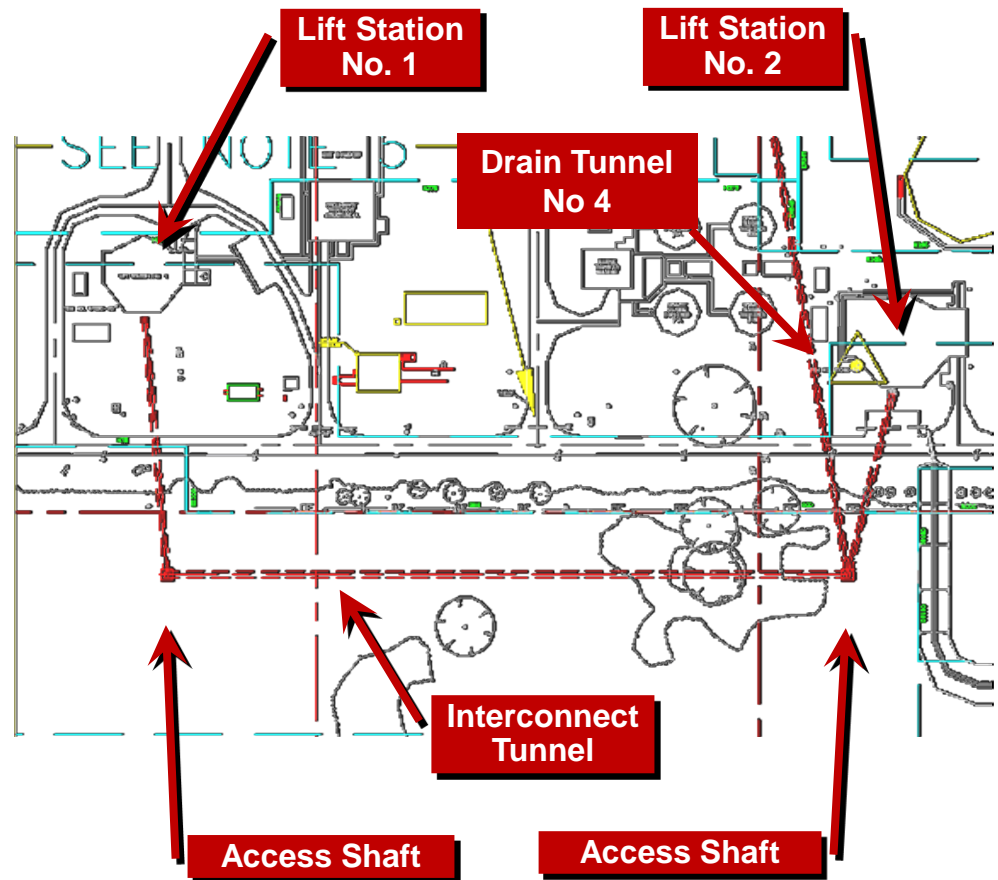
PROJECT BACKGROUND

- ✓ SARWWTP receives flow from the south half of Austin (SAR Service Area)
- ✓ PER confirmed flow from service area
- ✓ Flow from two separate service areas is delivered to the site via two tunnels
- ✓ Tunnels terminate in two separate lift stations approximately 90 feet deep
- ✓ No definition of division of flow



TUNNEL ROUTE

- ✓ Avoid Damage to Operating Facilities
- ✓ Minimize Interruptions of Plant Operations
- ✓ Tunnel Must be Constructible



TUNNELS BETWEEN ACCESS SHAFTS No. 2

- ✓ Access Shaft 1 to Access Shaft 2 – 768 ft
- ✓ Decker Model 70 TBM – 5.75 ft dia
- ✓ Hobas Pipe – 63 in.
- ✓ Downhill - 0.2%
- ✓ Taylor Shale



BACKFILL OF EXISTING LIFT STATIONS

- ✓ Probing Operations
- ✓ Compaction Grouting



SAGUARO RANCH TUNNEL



PORTAL CUT



HORIZONTAL BORING



PILOT TUNNEL



SHOTCRETE



TOP HEADING



FINAL TUNNEL



NEW CRYSTAL SPRINGS BYPASS (POLHEMUS) TUNNEL

Design
Challenges

By:

Dr. Gary S.
Brierley

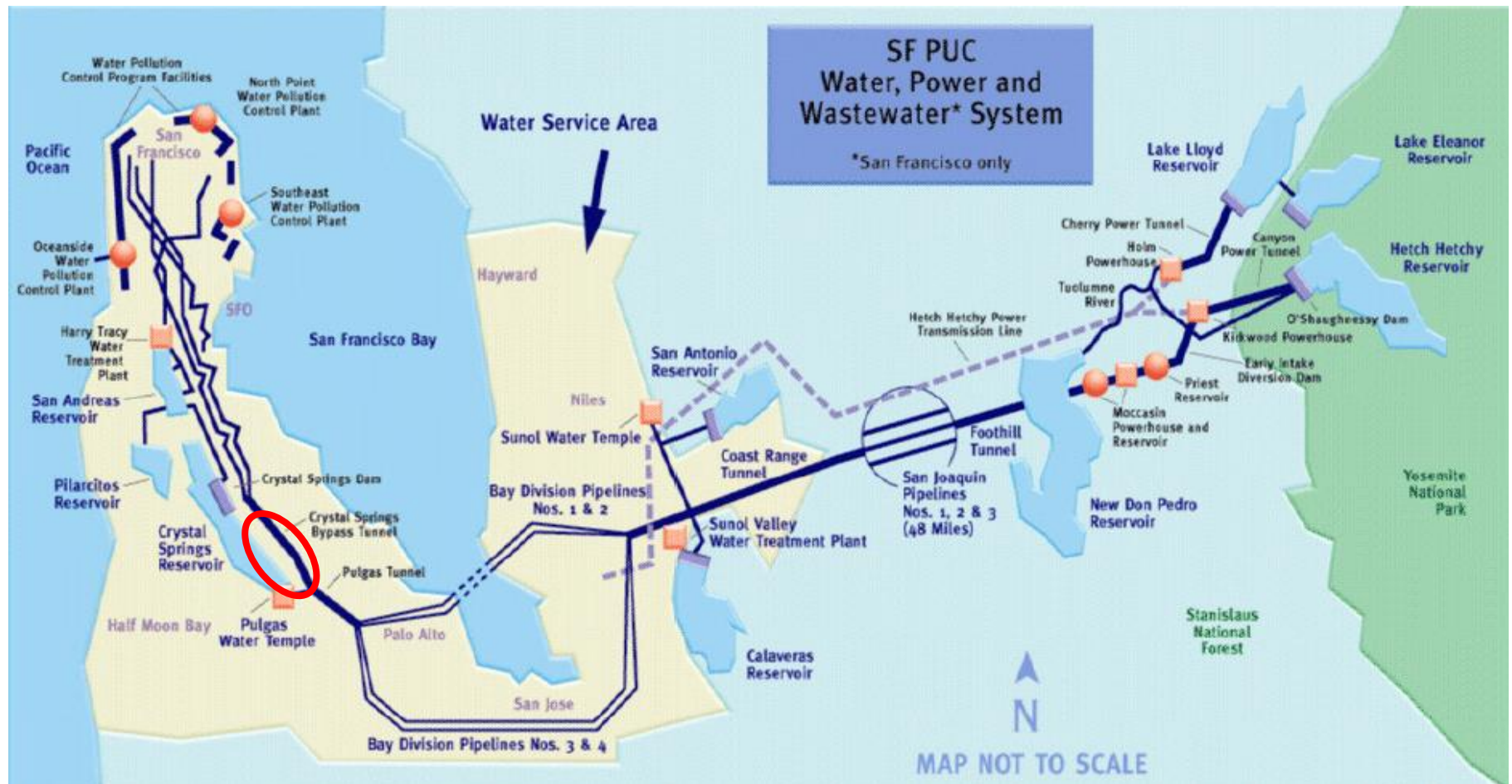
City And County Of San Francisco
Public Utilities Commission
San Francisco Water Department



Services of the San Francisco
Public Utilities Commission

SFPUC

WATER SUPPLY IMPROVEMENT PROGRAM





GROUND CONDITIONS

Sandstone

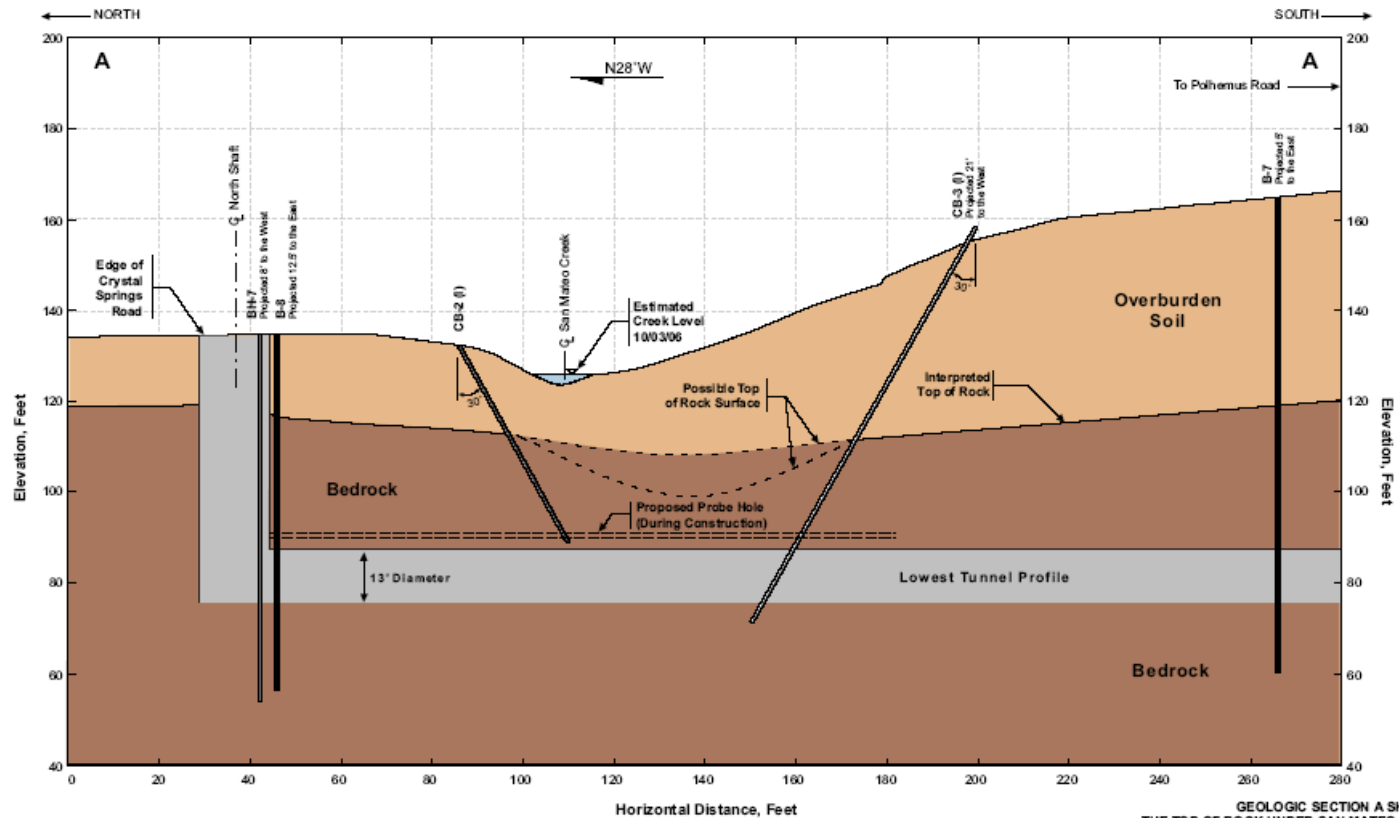


Mélange Matrix





CROSSING SAN MATEO CREEK



GEOLOGIC SECTION A SHOWING
THE TOP OF ROCK UNDER SAN MATEO CREEK;
COMBINATION VERTICAL AND INCLINED BOREHOLES

New Crystal Springs Bypass (Polhemus) Tunnel
San Francisco Public Utilities Commission

March 2006 San Francisco, California

ARUP BRIERLEY

PLATE 2



A Final Recommendation:
THINK! THINK! THINK!



SO, WHY DO YOU WANT TO WRITE A GBR?

By Gary S. Brierley, PhD, PE, F.ASCE

Lake Mead III Intake – Chamber Excavation;
Las Vegas, Nevada

The Geotechnical Baseline Report (GBR) concept premiered in 1974, in a report titled *Better Contracting for Underground Construction*. It was published by Standing Subcommittee No. 4 of the U.S. National Committee on Tunneling Technology, chaired by tunneling great, Al Mathews. The document includes the following paragraphs:

Geotechnical interpretation involves geological assessments of geophysical exploration, assessments of soil or rock characteristics such as relative strengths, hardness, induration, and degree of weathering or alteration, geological maps and sections, soil profiles, and all recommendations and comments pertaining to the design and construction of the works based on examination of the factual data.

In sum, all subsurface data obtained for a project, professional interpretations thereof, and the design considerations based on these data and interpretations should be included in the bidding documents or otherwise made readily available to prospective contractors. Fact and opinion should be clearly separated.

This quote was the beginning of a 40-year “love affair” with geotechnical reporting that has culminated in the current status of GBRs.

Since 1974, scores of papers, articles, conferences, and legal documents have been dedicated to explaining HOW to write and/or HOW to use a GBR. But the vast majority of geotechnical engineers, according to my research, still seem confused about WHY writing a GBR is necessary. Believe it or not, GBRs are an important component for the successful completion of complex projects that come into contact with large volumes of soil and rock such as highways, dams, large excavations, and particularly tunnels.

Why GBRs?

ASCE published the single-most authoritative GBR document in 2007. Titled *Geotechnical Baseline Reports for Construction, Suggested Guidelines*, the document provides the most definitive rationale for why a GBR should be written:

1.2 The Geotechnical Baseline Report

Projects involving subsurface excavation present many risks, all of which must be assumed by either the Owner

or the Contractor. The greatest risks are associated with the materials encountered and their behavior during excavation and installation of support. The main purpose of the GBR is to clearly define and allocate these risks between the contracting parties.

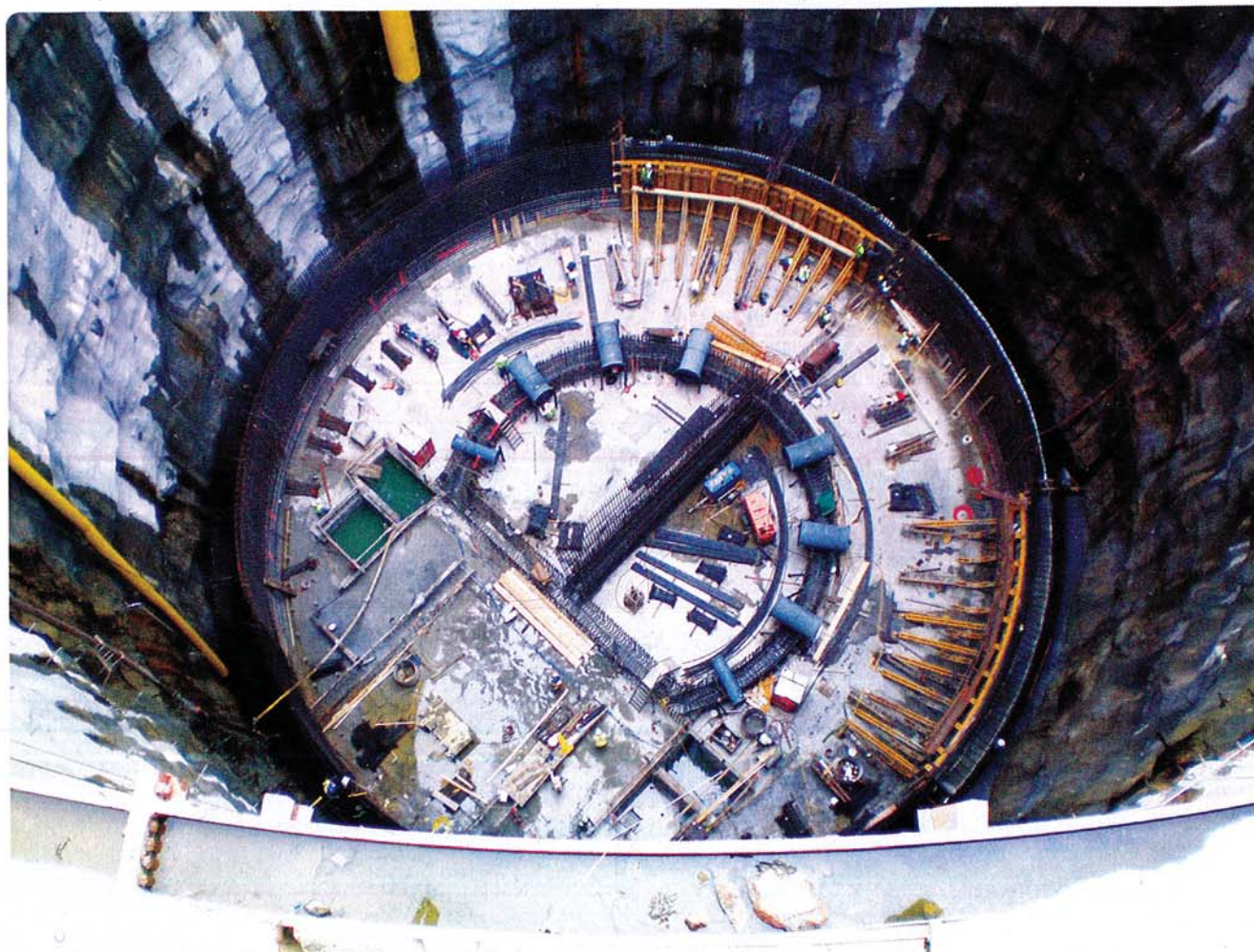
The GBR establishes a contractual understanding (interpretation) of the subsurface site conditions, referred to as baselines. Risks associated with conditions consistent with or less adverse than the baselines are allocated to the Contractor, and those significantly more adverse than the baseline are accepted by the Owner. The latter conclusion derives from the philosophy that the Owner owns the ground, as well as any obstructions in the ground. If conditions are determined to be more adverse than portrayed in the baselines, then the Owner pays any additional cost of overcoming those conditions.

Before GBRs, contractors would be given the results of subsurface explorations without any commentary about how those results might apply to any particular project. If difficulties were encountered, huge arguments ensued

Since 1974, scores of papers, articles, conferences, and legal documents have been dedicated to explaining *how to write and/or how to use a GBR*. But the vast majority of geotechnical engineers still seem confused about **why** writing a GBR is necessary.



Tollgate Interceptor Rehabilitation Project; Aurora, Colorado



South Cobb Tunnel – Circular Concrete Secant Pile Wall; Cobb County, Georgia

about whether or not the contractor had made “reasonable and prudent” assumptions and conclusions about how the subsurface conditions related to its proposed means and methods for constructing the project. Without belaboring this concept, it’s easy to state that each person’s view of what constitutes “reasonable and prudent” could be characterized as exceedingly elastic.

So to address the issue of what constitutes a “differing site condition,” it became commonplace to have the design team and the geotechnical engineer, rather than the contractor, establish baselines regarding various anticipated subsurface conditions. In essence, this is the primary reason WHY GBRs are now included as part of the contract document. But it’s not the only reason.

Third-Party Impacts. Tunneling projects in urban areas will encounter a huge number of potentially damaging third-party impacts, such as overlying utilities, building foundations, ground-surface settlements, and rivers, so it’s essential that both the designer and the contractor do what’s necessary to protect those third parties. Hence, geotechnical considerations associated with third-party impacts should be discussed in the GBR.

Dispute Resolution. GBRs are generally associated with the use of Dispute Review Boards (DRBs), and GBRs represent a very strong mechanism for helping DRBs resolve disputes. In fact, one of the primary reasons for writing a GBR is to serve as a roadmap for assisting the DRB. Because DRB members are design and construction practitioners, they are well-positioned to interpret the legitimate intentions of the design team based on their evaluation of the GBR, the GDR, the specifications, and the drawings.

Assistance with the Owner’s Estimate. It’s not possible for the design team to estimate the cost of a project without an adequate understanding of the subsurface challenges that will be encountered and must be overcome during construction. Therefore, the first group of individuals to use the GBR should be the trained and experienced tunneling professionals who prepare the designer’s cost estimate for the project.

One of the biggest problems associated with cost estimating for underground projects is establishing contingencies for potential problems. Contractors whose contingency allowances are too high will not be the low bidder. Contractors whose contingency allowances are too low

might not understand the challenges they face and cause a financial disaster for everyone involved with the project. One of the primary goals of the GBR is, therefore, to help define and control contingencies so contractors can establish an appropriate level of effort to achieve a successful project.

Field Observation. GBRs are also used as a field-observation guide by clearly setting the stage for what needs to be observed during construction for comparison with the baselines established by the contract document. Everything that was baselined needs to be observed in order to establish whether or not a differing site condition was encountered. If a claim is made, then it is these observations that will be summarized and presented during DRB hearings.

Risk Management for the Project. All aspects of subsurface risk should be discussed in the GBR. Foremost among geotechnical considerations during design should be a concerted effort to avoid and/or to minimize every risk associated with the project from the points of view of every project participant. Simply assigning risk, transferring risk, or pretending that risks don't exist, is not enough. When the contract documents are released for bidding, members of the design team must be satisfied that they have done a good job trying to avoid potentially destructive consequences.

Three primary types of geotechnical risk are associated with GBRs: subsurface data, geological interpretation, and ground behavior. Subsurface data are summarized in a Geotechnical Data Report (GDR), and these data should be comprehensive and accurate. Geological interpretation is based on thoughtful analysis by well-informed and experienced engineering geologists. Although it is difficult to predict every ground

condition that might occur between the test borings, an honest effort in that regard is necessary to prepare a GBR. Finally, the team responsible for actually writing a GBR must anticipate how the ground will behave and/or react to the specified tunneling methodology. Correctly anticipating ground behavior has important ramifications both for the tunneling operation and for overlying and adjacent third parties.

In order to build a tunnel, it is necessary to anticipate what is required to excavate the ground, what is required to control the ground during the excavation process, and what is required to support the ground as the tunnel is advanced. When it comes to support, the operative words are "safe and stable." Even when the face of excavation is thousands of feet from the portal, all portions of the tunnel must be safe and stable both inside the tunnel and with respect to third-party impacts.

Risk Allocation for the Geotech. Many geotechnical firms rely on ASFE/GBA's well-established approach to risk allocation, limitation of liability. Without going into great detail, this involves identifying the uncertainties associated with subsurface investigations, geologic interpretation, engineering evaluations, and the contractor's anticipated means and methods, in developing design recommendations. But almost none of these uncertainties apply to the preparation of a GBR. For instance: the ASFE/GBA concept of risk allocation is firmly rooted in what might be called a Regular Geotechnical Report (RGR) as compared to a GBR. An RGR provides geotechnical design criteria for a structural engineer or an architect, which has nothing to do with what is needed to construct what is shown on the contract drawings. A GBR, by contrast, provides geotechnical construction criteria for the contractor. For instance, when writing GBRs, the geotechnical engineer is part of a team that actually specifies construction means and methods and, as a result, must anticipate how those means and methods will interact with the ground as revealed by the subsurface explorations. Thus, the only way a geotechnical engineer can allocate risk when preparing a GBR is to:

1. Only work for Owners who understand and are willing to accept the issues and risks associated with underground construction. If an Owner insists on awarding the subsurface investigation to the lowest bidder, then avoid that Owner if you are being asked to write a GBR.
2. Use a DRB in combination with a GBR. DRBs may not be perfect, but they provide a far better option than going to court. Seasoned professionals must be available to work out the technical intricacies associated with underground construction.
3. Do a good job writing your GBR and make certain that it is compatible with all other project specifications and drawings. GBRs are not a good vehicle for on-the-job training! Know what you are doing and put a lot of thought into writing your GBR. The primary objective of a GBR is to make certain that the project is constructed in a proper manner.

As an example of this distinction, suppose a geotechnical engineer is tasked with providing foundation design criteria for a 10-story building with two levels of underground parking

Before GBRs, contractors would be given the results of subsurface explorations without any commentary about how those results might apply to any particular project.



**Automated People Mover Tunnel System;
Dulles International Airport, Virginia**

on a site that has no important third-party impacts. The test borings and laboratory test results are used to determine soil properties, and the geotechnical engineer provides design values for allowable bearing pressure for the footings and allowable lateral earth pressures for the foundation walls. During construction, the contractor decides, based on the test boring results, to drive sheet piles for the foundation excavation and encounters cobbles and boulders that were not indicated by the borings. Later, it's revealed that the soil deposits are actually glacial till, which results in delays, costs, and claims.

If a GBR had been prepared for this project, then the geotechnical design criteria would have been presented in a separate Geotechnical Design Memorandum (GDM), and the emphasis of the GBR would have been placed on how to build the project rather than how to design it. This is not to say that one report format is good and the other bad — only that they are different, with different objectives and risk profiles. In order for the geotechnical engineer to be successful, therefore, it's necessary to understand these differences and to make certain that reports are compatible with different types of underground projects and different types of risk allocations.

When to Write a GBR?

A GDR needs to be available to design-team members at the 30 percent design stage. That's when the GDR will be used to produce Geotechnical Design Memoranda (GDMs) and to set the stage for all of the "brainstorming" required for contract preparation. The best time to actually write a

GBR is at the 90 percent design stage. At that time, all of the project drawings and specifications will be available, making it possible to ensure that all of the contract documents are consistent with whatever is necessary to construct the project. Consistency among the contract documents is one of the keys to success for GBR preparation.

Embracing GBRs

Although these concepts may be difficult to understand and even more difficult to accept, the risk is actually reduced for geotechnical engineers who fully embrace the GBR approach to underground construction. Geotechnical engineers who write GBRs become part of a team that:

- conducts a comprehensive subsurface exploration,
- participates in discussions about contracting practices and anticipated construction activities,
- evaluates and discusses options for avoiding, minimizing, and addressing subsurface risks,
- follows through into construction to observe ground behavior, and
- participates in dispute resolution concerning any problems that may develop during construction.

When done properly, the GBR process represents the epitome of what geotechnical engineering OUGHT to be — and that may be the best reason of all for us to write them.

The best time to actually
write a GBR is at the 90
percent design stage.

AUTHOR

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To GBR Or Not To GBR; Is That The Question?

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ABSTRACT

This paper discusses the practical aspects of preparing Geotechnical Baseline Reports. Guidelines for the preparation of Geotechnical Baseline Reports were established in the ASCE publication entitled, “Geotechnical Baseline Reports for Construction,” dated 2007. However, the practical aspects of actually writing a Geotechnical Baseline Report and the risk assumptions associated with this document are highly controversial. Not every project needs a Geotechnical Baseline Report and not every geotechnical engineer is equipped to write one. This paper will provide its own set of guidelines for the preparation of Geotechnical Baseline Reports. The paper suggests that Geotechnical Baseline Reports are one contractual format for handling such as third party impacts and differing site conditions that often arise when involved with subsurface construction.

INTRODUCTION

The American Society of Civil Engineers (ASCE) has published a document entitled “*Geotechnical Baseline Reports for Construction, Suggested Guidelines.*” This document was sponsored by both ASCE and the Society of Mining Engineers and was prepared under the auspices of the Underground Technology Research Council. It was the work of the Technical Committee on Geotechnical Reports which is chaired by Randy Essex. Two editions of the report have been published; one in 1997 and the second in 2007. Hence, these guidelines have been part of the geotechnical profession for more than 15 years. Given below are excerpts from ASCE’s GBR Guidelines that define its purpose and scope:

1.2 The Geotechnical Baseline Report

Projects involving subsurface excavation present many risks, all of which must be assumed by either Owner or the Contractor. The greatest risks are associated with the materials encountered and their behavior during excavation and installation of support. The main purpose of the GBR is to clearly define and allocate these risks between the contracting parties.

The GBR establishes a contractual understanding (interpretation) of the subsurface site conditions, referred to as baselines. Risks associated with conditions consistent with or less adverse than the baselines are allocated to the Contractor, and those significantly more adverse than the baselines are accepted by the Owner. The latter conclusion derives from the philosophy that the Owner owns the ground, as well as any obstructions in the ground. If conditions are determined to be more adverse than portrayed in the baselines, the Owner pays any additional cost of overcoming those conditions.

1.3 Purpose of the GBR

The principal purpose of the GBR is to set clear realistic baselines for conditions anticipated to be encountered during subsurface construction, and thereby provide all bidders with a single contractual interpretation that can be relied upon in preparing their bids. Other key objectives of the GBR include:

- Presentation of the geotechnical and construction considerations that formed the basis of design for the subsurface components and for specific requirements that may be included in the specifications;*
- Enhancement of the Contractor's understanding of the key project constraints, and important requirements in the contract plans and specifications that need to be identified and addressed during bid preparation and construction;*
- Assistance to the Contractor or DB team in evaluating the requirements for excavating and supporting the ground; and*
- Guidance to the Owner in administering the contract and monitoring performance during construction.*

In general, the GBR approach seeks to accomplish the following three primary objectives:

1. Tell the Contractor what to expect when he/she goes underground.

2. Tell the Owner at what point he/she becomes liable for a “differing site condition.”
3. Tell “everyone” what they need to know about anticipated ground conditions and the challenges of construction.

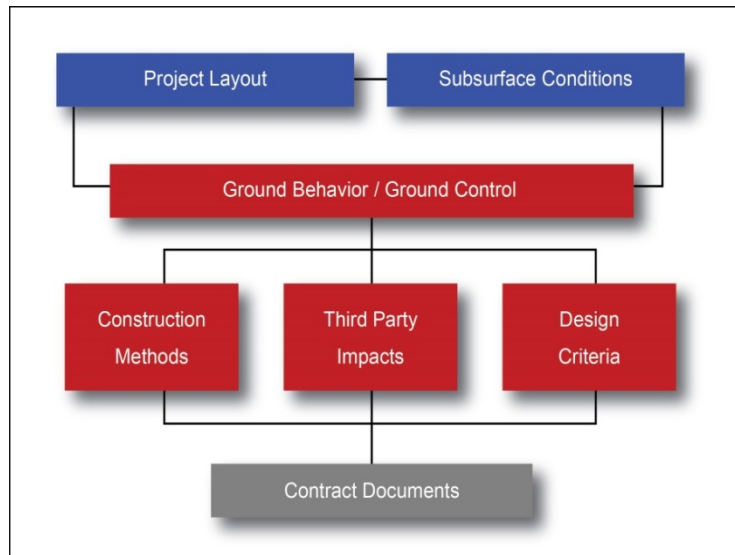
Assuming for the moment that this is a valid objective for someone of the geotechnical persuasion, how would one go about accomplishing such a task?

1. You must know a lot about the ground. Clearly, if you become involved with the preparation of a GBR, then you must be authorized to conduct a thorough subsurface investigation. Although budgetary constraints are a reality we all face, if anyone tries to limit you with respect to the subsurface investigation, then do not even think about writing a GBR.
2. You must know a lot about what it will take to both design and to construct whatever is necessary for the project. GBR’s are not a good vehicle for on-the-job training. In general, you should have at least ten years of experience before writing a GBR.
3. You must work as a team in the preparation of a GBR. No individual, no matter how smart and/or how experienced can write a GBR all by themselves. Brainstorming, risk evaluation, design options, construction procedures, third party impacts, ground improvement procedures and many other variables all become part of a GBR.
4. The GBR must be compatible with all other portions of the contract document including all of the specifications and the drawings. You cannot say something in the GBR and then produce contract specifications or contract drawings that are at odds with those statements. You may think that this would be a fairly straightforward process but the authors of this article can assure you that it requires particular attention.
5. You must be working for a project Owner who both understands and accepts the risk allocation assumptions that are implicit in the GBR approach to project procurement. If you think that the Owner will lash out at you if something isn’t quite right, then you should avoid becoming involved with writing a GBR.
6. And, finally, if something does go terribly wrong on your project then you will be dragged into a big claim. Hence, it is beneficial if you have people on staff who know how to deal with insurance companies and attorneys.

THE GEOTECHNICAL BASELINE REPORT

How to Prepare a GBR

Given below is a Flow Chart that the authors of this article use to assist them in preparing GBR's.



In order to implement a brainstorming session for a GBR, someone must describe all aspects of what needs to be designed (i.e. the project) and the characteristics of the soil, rock, and groundwater in which construction activities will take place (i.e. subsurface conditions). Following these presentations, the group will then discuss how the ground is expected to “behave” during construction. During this discussion, comments about project design and construction and about potential third party impacts are recorded with a particular emphasis on the geotechnical risks that exist for this particular project.

Following your initial evaluation, it is possible to go back and discuss ways to modify the project layout and/or the ground conditions in order to create a more favorable risk profile for the project. For instance, if the project is a tunnel, you might discuss moving a shaft or changing either the vertical or horizontal alignment of the tunnel. For the ground, you might decide that construction dewatering, grouting or freezing would produce a much improved subsurface environment for construction. Having made these changes, it is then possible to go back and re-evaluate your list of design, construction and third party exposures until you obtain the best possible combination of options for your project. At that point in time, you then decide what contract specifications and drawings are required in order to implement your plan for the project. You also organize all of your notes from the brainstorming session for inclusion in the Geotechnical Baseline Report.

Clearly, the procedure described above is more of an art form than a set of hard and fast scientific principles. It is also beyond the scope of this paper to describe how one goes about actually writing a GBR which is the topic of the “Guidelines” publication by ASCE, which should be obtained by anyone contemplating writing a GBR. Contained herewith in the remainder of this paper are discussions of numerous subsidiary issues that must be kept firmly in mind by the geotechnical engineer tasked with preparing a GBR.

Motivating Factors

There are two primary motivating factors for the preparation of a GBR:

1. The differing site conditions (DSC) clause, and
2. Third-party impacts.

If the construction contract includes a DSC clause, then something must be done in order to set the stage for what constitutes a “differing site condition.” Hundreds of reports, thousands of pages of discussions and almost 100 years of legal precedents have been provided with respect to this topic and a complete discussion of the nuances of differing site conditions is beyond the scope of this paper. When all is said and done, however, it is an indisputable fact that it is the geotechnical engineer to whom people turn when allegations of differing site condition rear their ugly heads. The GBR approach is one method whereby the entire Owner/Designer team can manage/implement their responsibilities with respect to the DSC clause.

With respect to third party impacts, if something goes wrong on a construction project it is bad enough that the consequences of that problem will impact the Owner, the Contractor, and the Designer. In addition, however, if the problem results in severe, negative impacts to adjacent third parties then the costs associated with that problem can spiral out of control. Hence, one of the primary motivations associated with the GBR approach is to evaluate and isolate negative third party impacts from your project to the best of your ability.

The Geotechnical Data Report (GDR)

If you plan to write a GBR, then you will also need a GDR. In fact, the authors of this paper would go so far as to say that a good GDR is one of the most important foundations of a good GBR. Put simply, the GDR is one complete assemblage of all geotechnical facts associated with your project. All subsurface facts about what was done, where it was done and what was learned from those activities must be assembled in one report. Each test boring, geophysical investigation, and laboratory test result must be described and the results of those activities summarized in tables,

graphs, and plots. Equally important for this report is that no attempt is made to interpret and/or to describe the significance of any of those facts. For instance, you would not include a subsurface profile in the GDR. Upon completion, the GDR should become part of the contract and no attempt should be made to disclaim the data.

Geotechnical Interpretation

There are several levels of geotechnical interpretations that are necessary for a GBR; the first of which is geological. One must develop a strong geological basis for the interpretation of the subsurface investigations that results in a geological profile for the proposed project. Everyone involved with an underground project will turn to the geological profile for a basic understanding of what to expect underground and a solid understanding of the geological processes that created each particular ground condition is essential. Engineering geology is one of the cornerstones of a good GBR.

Following geological interpretation is soil and rock mechanics interpretation. Based on laboratory test results it is necessary to describe the soil and rock properties associated with each deposit and the groundwater regime that is superimposed on those properties. Good summary tables, histograms and other forms of data summary can be used to assemble a list of soil and rock properties that will impact ground behavior during construction.

Finally, the team associated with GBR preparation must anticipate how the ground will behave and/or react to construction activities. Does the ground contain obstructions? Is the ground basically stable or will it squeeze, flow, swell or otherwise behave in a manner that will result in negative impacts? Will groundwater pressure result in additional ground instabilities during construction and/or produce large water inflows that must be managed? Is it possible that ground behavior might impact adjacent and/or overlying existing facilities? Each of these topics must be discussed and evaluated relative to what should be presented in the GBR.

At this point in the process it is important to realize that nothing has been written about the GBR, only discussed. Hence, the final interpretive effort is to make a conscious decision about how all of the interpretive discussions should be characterized in the GBR. Sometimes the best aspect of a GBR is to describe what the team believes will not work for a particular project. For instance, if boulders are present then it is safe to say that sheet piling should not be used for the support of excavation. Or, for extremely fine grained soils, possible problems associated with construction dewatering could be documented. In any case, based on facts, experience, judgment and geotechnical and geological knowledge, one prepares a written report that establishes a working model for the ground in which the project

will be constructed. This report is referred to as a GBR. From experience, the authors of this paper refer to this issue as an excellent application of the Goldilocks Principle; i.e. do not write too much and do not write too little. Tell the contractor what he/she needs to know in order to build the job in a satisfactory manner, but do not say so much that every aspect of the means and methods of construction is dictated. Also, do not attempt to repeat construction requirements that are clearly stipulated in the specifications and the drawings. Say it once, say it clearly, and avoid contradictions.

The subsurface profile is one of the most important geotechnical interpretations to be provided in the GBR. DO not provide a subsurface profile in the GDR! The subsurface profile is an interpretation and does not belong in the GDR. The subsurface profile represents the basis for just about every interpretation that will be provided in the GBR. It also represents the sum total of all subsurface information available about the project, included all geologic information, all geotechnical data, all information from adjacent projects, all historical documentation, etc., etc. You will not visit many construction sites for tunneling projects without observing the subsurface profile taped to the wall of the construction trailer. The bottom line; put a lot of thought into the preparation of your subsurface profile before it is included with your GBR.

One final item with respect to Geotechnical Interpretation; do you baseline the soil or rock property or do you baseline the construction impact? For instance, do you baseline permeability or how much water will enter the tunnel? Do you baseline unconfined compression strength or the impact on TBM performance? Do you baseline rock mass characteristics or how much support will be required? In general, you are better off baselining what you can see and/or measure in the tunnel rather than a soil or rock property but, once again, there are no hard and fast rules. Sometimes you do one or the other. Sometimes you do both. Sometimes you let the data speak for itself. Good judgment, adequate knowledge and experience are the keys to success.

Geotechnical Reports

There are several aspects of a GBR that must be kept firmly in mind as compared to what might be called a “normal” geotechnical report. For instance, given below is a listing of items that one would consider for a geotechnical report for a building foundation:

1. The recipient is a structural engineer or an architect.
2. The building is on private property.
3. The number of third party impacts is limited.
4. The primary focus of the report is geotechnical design criteria.

5. The ground conditions are fairly well known based on previous projects.
6. The contractors are local and probably know as much about the ground as the geotechnical engineer.

For comparison, given below is a listing of items that one should consider when writing a GBR for a tunneling project:

1. The recipient is a contractor via the contract document.
2. The project will be located almost entirely below public property.
3. There may be literally hundreds of third party impacts.
4. The primary focus of the report is what is required to produce a satisfactory finished project.
5. The ground conditions are well outside what is generally known for building foundations.
6. The contractors may be large national or international firms who know nothing about local subsurface conditions.

Clearly, it is not possible to use everything that you know about “normal” geotechnical reports in order to prepare a GBR. In fact, it is possible to state that the two activities are almost mutually exclusive. Do not be lulled into a false sense of security that it might be interesting and/or fun to write a GBR if you do not have the requisite background and experience. GBR’s can become extremely contentious if the project does not go well for any reason.

It must also be noted that the primary recipient of a “normal” geotechnical report is the Designer, while the primary recipient of a GBR is the Contractor. In all honesty, the Contractor really doesn’t care about design criteria unless they will impact his/her operations. Hence, there is no need to discuss design criteria in a GBR in great detail. In order to solve this problem, the geotechnical engineer should prepare one or more “Geotechnical Design Memoranda” (GDM) that are addressed specifically to the Designer. This approach solves two problems simultaneously.

1. It does not confuse the objective of the GBR with language that is not required for its intended purpose.
2. And, it provides the Designer with exactly what he/she needs to know in order to design the project without becoming part of the contract document.

All GDM’s should be made available to the contractor “for information only.” There is often a desire by the Designer or the Owner to withhold the GDM’s from the Contractor, but it is author’s experience that this causes harm if a claim situation arises. These documents will be revealed in legal discovery and are attached as superior knowledge which can be very damaging to the Owner/Designer.

What Geotechnical Issues Should Be Baselined

There are no hard and fast rules about what portions of the GDR should be baselined. Rock strengths, water inflow, obstructions, and other items as discussed in the ASCE Guidelines document are obvious candidates, but each project will have a unique list of concerns depending on ground conditions, anticipated construction procedures and third party impacts. Experience and judgment are the best and probably the only guide to this decision.

Another topic that is frequently asked is what happens to all of the geotechnical data that is not baselined. Some parties have attempted to claim that if baselines are not provided, then the contractor is not allowed to file a claim with respect to that aspect of subsurface performance. Nothing could be further from the truth. If no baseline is provided, then the data rules. All that is required is for the contractor to make a reasonable and prudent interpretation of the data; just like the good old days before the preparation of GBR's. Any attempt by the owner and his legal advisors to disclaim the geotechnical data will in all likelihood meet with failure.

Contractual Consistency

It is absolutely imperative that the GBR is internally consistent with all of the other contract documents including the general and special provisions, the specifications and the drawings. In general, it would seem to be a simple matter accomplish this task but different groups of individuals prepare different portions of the contract at different times and no one takes the time to read the entire document before it is released for bidding. After release, it is embarrassing to see scores of pages of addenda attempting to correct all of those inconsistencies. Despite all best efforts, subsurface information might be right or wrong but it should never be confusing or contradictory. It is a simple matter for the Contractor to make a claim if the contract is internally inconsistent.

The Timing of Geotechnical Reports

Another question that is frequently asked is what is the best time during project completion to prepare the GDR and the GBR? Subsurface data is so important that it should be available to all participants of the design team by 30% project completion. Geotechnical Design Memoranda can be prepared at any time during design on an as-needed basis. Likewise, various portions of the GBR can be prepared as design progresses but the first real draft of the GBR should be targeted for about 90% project completion. It is at this time that the vast majority of other project documents will be available and provide the greatest opportunity to accomplish the goal of contract document consistency.

Safety

There is nothing associated with subsurface investigations, geotechnical report preparation, field observations, or any other aspect of underground design that in any way relieves the Contractor from his/her responsibility for safety. NO matter what is said in the GBR, the Contractor is 100% responsible for the safety of his employees in the field. A careful reading of OSHA regulations makes this fact perfectly clear unless the geotechnical engineer does something and says something that would cause someone to believe otherwise. The authors of this paper include a paragraph in our GBR's making this fact perfectly clear, including a sentence that says the Contractor is responsible for providing a "Competent Person" at the site as defined by OSHA. All geotechnical engineers must train their own field staff to conduct themselves at a site in accordance with acceptable OSHA protocols for safety.

Construction Observations

It is imperative that any project that has a GBR as part of the contract document also has full-time observation of construction practices including active participation from geotechnical professionals. Every claim of differing site conditions contains a huge element of he said/she said commentary about what happened underground and it is imperative that each contracting party have detailed notes about ground conditions and construction activities. There are times that despite all best efforts by all parties to a contract, something nasty happens underground that no one anticipated. Mother Nature can be extremely unkind and uncooperative. If that happens, then the DSC clause says that Owner becomes responsible for the costs associated with all related construction impacts. It is impossible to decide what those costs are unless both sides to the conflict have good construction records from the field.

Contaminated Ground

Contaminated ground, either natural or man-caused, can have huge negative impacts on an underground project. An inability to dispose of the ground and/or the water from an underground project means that the project is shut down. In addition, contaminated ground can result in severe restrictions on worker productivity. The GBR must make clear that it is not the document for an evaluation of environmental concerns. Environmental professionals must be hired to conduct an equally thorough and comprehensive assessment of ground contamination as compared to the subsurface investigation. Ideally, these two firms can work together cooperatively, but the geotechnical engineer should not assume responsibility for ground contamination.

The CYA Factor

Many geotechnical engineers view the GBR as an opportunity to protect themselves and their client from subsurface risk by exaggerating various geotechnical parameters. For instance,

1. If you think the contractor will encounter 5 to 10 boulders, say 100.
2. If you think the rock has an unconfined compressive strength of 8 to 10,000 psi, say 20 to 25,000 psi.
3. If you think the contractor will encounter will encounter 500 GPM of water in the tunnel, say 5,000 GPM.

This is a very bad idea. The GBR criteria must be true to the data. It is OK to place some reasonable contingency on what the data reveals but if you overdo it, then you are exposing yourself to a contractual backlash that can become extremely unpleasant. It is difficult to explain in this short paper all of the possible legal and contractual ramifications of the CYA factor, but the GBR should be a reasonable interpretation of what the data reveals.

An equally bad idea is to believe that if you provide unreasonable or irrational baselines, then you can ask for money back if the ground turns out to be “better” than anticipated! Any attempt to enforce this requirement in the contract means that your project will become highly contentious and that you will spend a lot of money on attorneys. The entire GBR philosophy revolves around Owner/Contractor cooperation. Clearly, the CYA approach to GBR preparation has nothing to do with cooperation.

Standard of Care

Based on the above discussion, it is possible to state that there are two distinctly different approaches to the preparation of geotechnical reports. If you are involved with the types of projects where GBR's are used such as tunnels, dams, highways, and other major subsurface projects, then you must think very carefully about which type of report you intend to prepare and you should clearly state your intentions in the introduction and the limitations of your report. As stated above, confusion is not a good outcome for your efforts. Even if you do not use the GBR format for any reason, the overall purpose and the intended objective of your work should be clearly understood by all potential readers.

CONCLUSIONS

Differing site conditions and negative third party impacts are the nemesis of subsurface construction. Sometimes despite all best efforts, things happen

underground that no one anticipated and which result in costs and delays for construction projects. How best to anticipate, to manage, and to deal with these unfortunate events is a source of almost infinite discussion in the geotechnical profession and Geotechnical Baseline Reports are one contractual format for dealing with this issue. Given below are two conclusions about GBR's that appeared in previously published papers that are still relevant to this topic. The first was written by David Hatem of the law firm Donovan Hatem who has considerable experience with GBR's. The second was written by Dr. Brierley for a book entitled "Subsurface Conditions," published by John Wiley & Sons in 1998.

By Mr. Hatem:

The baseline approach is a relatively new, innovative and somewhat controversial contracting practice. In many respects, the baseline approach, if prudently implemented, does represent a potentially and significantly positive, and constructive opportunity to minimize conflict, disputes and claims involving differing site conditions. However, the professional liability risk associated with the use of the baseline approach must be anticipated and recognized. As in the case of most risk, this professional liability risk can be effectively managed and contained. Hopefully, this paper has assisted in discussing the factors relevant to the identification and management of this professional liability risk.

By Dr. Brierley:

Despite an attempt on the part of this author to provide a clear and comprehensive discussion of the topic of geotechnical report preparation, there is still more left unsaid about this topic than was covered here. The number of project types, ground conditions, and third-party impacts and the number of owner/contractor teams involved with underground projects is so large that it is simply not possible to discuss every possible combination of problem that might be encountered at a site. Competent geotechnical engineering is a function of theoretical knowledge, practical experience, and professional judgment that can be accumulated only over years of effort. Many writers about this topic have characterized geotechnical engineering as more of an art than a science, and a strong argument can be made in support of that statement. Trying to second-guess Mother Nature on a regular basis while, at the same time accurately assessing all manner of design and construction options for a site can only be characterized as one of the greatest challenges of civil engineering.

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