CONSTRUCTION SITE PLANNING AND LOGISTICAL OPERATIONS

Site-Focused Management for Builders

edited by
Randy R. Rapp
Bradley L. Benhart

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Purdue University Press
West Lafayette, Indiana

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Impact fees are the costs associated with public utilities and the impact that the project will have on the local services provided by the municipality. These fees can include support for sanitary sewer expansion, electrical services expansion, water services, fire and emergency services, road improvements, public school construction, and so forth. Visit www.impactfees.com to start accessing information on local impact fees broken down by state, county, and city location.

PREFACE

This book is written to help construction professionals improve on-site management of building projects. It should be valuable for aspiring and current superintendents and for upper-tier construction management or construction engineering baccalaureate students who expect to serve professionally on building construction jobsites.

The editors became convinced that this book is needed, as none currently written seems to cover the subject quite as they wished to teach it in the Building Construction Management courses they teach at Purdue University. Perhaps the book closest to it is the locally published *Construction Site Planning* written by our colleague, Dr. Fredrick "Fritz" Muehlhausen, who taught thousands of students about jobsite logistics in his course of that name. One can find multiple books that cover many of the subjects, but no one book captured enough of what we believe to be essential for good site operational and logistical management. None quite pulled together the predominant topics that we have found must be known to enhance the performance of field professionals.

The content draws from both the technical and the managerial realms. Jobsite supervision often demands integration of many competing concerns in order to plan and direct operations that simultaneously satisfy requirements imposed for schedule, budget, quality, and safety. The book is structured to first provide much of the focused technical knowledge, which informs the jobsite leadership, management, and control processes. All authors are seasoned practitioners and educators, and well versed in what they hope to convey. The book includes some international perspectives provided by James O'Connor of Dublin Institute of Technology. Of course, many of the fundamental planning and supervisory concepts apply globally. The reader might note minimally more repetition of some concepts in this book than in others, but the chapters must stand alone reasonably well in order to be individually available.

If the book proves as helpful to field professionals and students as we hope it will, then there are many supervisors, colleagues, clients, and students who share in whatever credit the book merits. Their generous guidance, insights, demands, and questions over the decades have added much that our observations alone would not have offered. We thank Professor Wayne Reynolds, PE, lately the construction management degree program director at Eastern Kentucky University, and Dr. Michael Emmer, associate professor in the construction management degree program at Roger Williams University, for their valuable assessment of the manuscript. Any errors remain the responsibility of the editors and authors.

Randy R. Rapp
Bradley L. Benhart
West Lafayette, Indiana

TABLE OF CONTENTS

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SECTION I

THE PROJECT AND SITE PREPLANNING

Many construction veterans say that a successful superintendent is like the conductor of an orchestra:

- Musicians = workers.
- Instruments = tools and equipment.
- Paper music = plans and schedule.
- Resulting music = the completed building.

Each day, the superintendent is planning the work (writing the music) and executing the plan. Without the superintendent, the workers are left to interpret the music without direction. They can make it for a short period of time but will often fall out of time without the superintendent there to keep them together.

While this entire book will explore the processes and skills required to be a great superintendent, this section will examine the preplanning that goes into a successful project from the site perspective. A great builder once said, "You make money in the office; you keep from losing it in the field." While this quote is often unpopular with superintendents, it does bring up a good point. The profitability on a construction project is typically targeted early on, during the bid or negotiations. While all the authors of this book strongly advocate the involvement of the field staff during the bid process, we recognize that this is often unrealistic. Most teams are left with the task of planning after the job has been awarded. Either way, the more preplanning a superintendent does, the more efficient the project will run.

Section I will highlight traditional basics required of planning a project coupled with new technologies that now aid a faster and more accurate plan. The foundation will be set with a look at a typical project site in perspective, including today's economic pressures. Preparing and recognizing for the unknowns will be reviewed in chapter 2—Due Diligence. Lastly, the book will utilize some of the most recent software systems and how they can save the superintendent time and money during the initial project planning.

CHAPTER 1

THE PROJECT AND SITE ENVIRONMENT

Randy R. Rapp, DMgt, PE, CCP

INTRODUCTION

The construction industry offers dynamic, challenging, and rewarding work. The special features of every building project guide and constrain contractors in their goal to fully satisfy their contracts with owner-clients while enabling contractor profitability.

Construction projects are unique, site-specific endeavors that last for definite time periods and employ material, labor, and equipment technologies unlike those in other industries. Project team members are the shareholders formally linked by interlaced contracts and agreements. They include the owner-client, the designer, the general contractor (GC) or construction manager (CM), subcontractors, vendors, craftsmen, and laborers. How the project team members are organized and interact will change with the method of project delivery and the team members' complex desires and needs. Other stakeholders, such as neighbors and interested governmental and nongovernmental special interests, impose still other opportunities and constraints. The work of building construction contractors and way they deliver value to the project owner-client are different from project activities in other industries. The challenge of managing activities on the site is a big part of what makes building construction special.

LEVELS OF MANAGEMENT

Executive or Enterprise Level

The top management team (TMT) of a company determines the strategic objectives and drives the broad decision-making and planning that keeps the firm viable. A TMT generally consists of the company's president and chief executive officer (CEO) as well as all who directly report to them. The best TMTs ingrain strategic thinking—not just strategic planning—throughout their organizations. That kind of thinking looks at enterprises and everything they do in their quest to keep the company economically competitive in the industry. The strategic time horizon of executive managers should be long, looking ahead many years. In theory, looking broadly and many years ahead makes executive management different from project-level supervision, which is the subject of this book.

Operational or General Level

The operational level bridges activity from the executive level to the project level, guiding project activities to attain strategic objectives. It is within this realm that programs of multiple related projects are developed. For example, a general contracting firm in the past might construct buildings only by traditional design-bid-build (DBB) delivery, which is a delivery system whereby an architect first completes a design for which the owner then invites bids in order to select the lowest offer among competing contractors. Later, the firm, while perhaps analyzing the market, might decide that the time is ripe to seek design-build (DB) projects, which is a delivery system whereby one legal entity performs both the design and construction phases, making the post-design contractor bidding time of DBB unnecessary. Saved project time makes DB delivery attractive. The firm then might develop a DB program of indefinite duration, lasting as long as top managers desire to pursue DB projects. Programs can last as long as the company exists or can be of shorter duration. The challenge for general or program managers is to simultaneously juggle the often-competing resource demands of multiple projects.

Project Level

A project is an endeavor to create a unique product with assigned resources and a distinct start and finish. The word *value* often crops up when discussing business ventures such as construction projects. Projects are the value-generating actions of business enterprises. The contractor's profitability commonly correlates positively with the amount of value created by the firm's portfolio or array of projects. Value for both the owner-client and the contractor is measured by the profitability they derive from the project. If the project is not expected to create value exceeding its costs for the owner-client, then the project will not happen. The contractor therefore works to sequence its activities and integrate its assets to develop this value for the owner-client.

The object of a project and any related contracts is performance that safely accomplishes the owner-client's desired work on time, within budget, and with an acceptable quality of materials and workmanship. These broad project objectives usually apply to the production of goods and services in any industry, but achieving them for building construction can be especially challenging because the varying characteristics among constructed projects makes each project unique.

Site location, building design, ongoing owner involvement during the work, productivity factors, and task scheduling all combine to differentiate construction from the work of other industries. The details differ among construction projects. Combinations of the following conditions differentiate a construction project from other industry projects:

1. With few exceptions, the total construction project process involves several organizations that design and build the project. Different organizations design and build the project, except for some projects delivered by DB, where the same company may do both. Even in the DB case, subcontractors almost always construct some of the building.
2. Within the same firms and depending on their expertise, project team professionals often change in successive projects.
3. The preponderance of direct labor applied to a project typically comprises a wide variety of formally defined trades and closely supervised trade crews.
4. The many tradespeople assigned to the work often change during the project, creating a "day labor" aspect to construction. Worker turnover during a longer project may exceed 100%.
5. Weather can be expected to regularly influence project costs and completion dates.

6. Logistical matters are critical; comparatively large weights and volumes of material must be transported to and remain in the completed project. This underlies much of the subject matter of this textbook.
7. Construction projects may be located far from any other facilities and require almost complete self-sufficiency and independent sustainment of the workforce, such as in construction camps.

Figure 1-1. Highly restricted work sites adjacent to buildings, as shown in this image from Florence, Italy, can require elaborate and costly scaffolding for access. The planning and permitting for such temporary works are seldom trivial.

VALUE CHAIN ACTIVITIES

The value chain activities of figure 1-2 include design, which might be thought to pertain more to DB project delivery. However, the responsibility for many design details on almost any building project lies with the GC, and the subcontractors' design expertise often makes them essential to installing the desired functionality into building systems. The project manager (PM) and the project superintendent commonly have the authority and responsibility to organize the detailed tasks within the value chain to best serve the client and enhance the profit margin. The superintendent's concerns are predominantly with on-site operations planning and execution. The superintendent can improve project performance by working smartly with the PM to leverage the supporting functions of the company to improve the efficiency and effectiveness of site tasks.

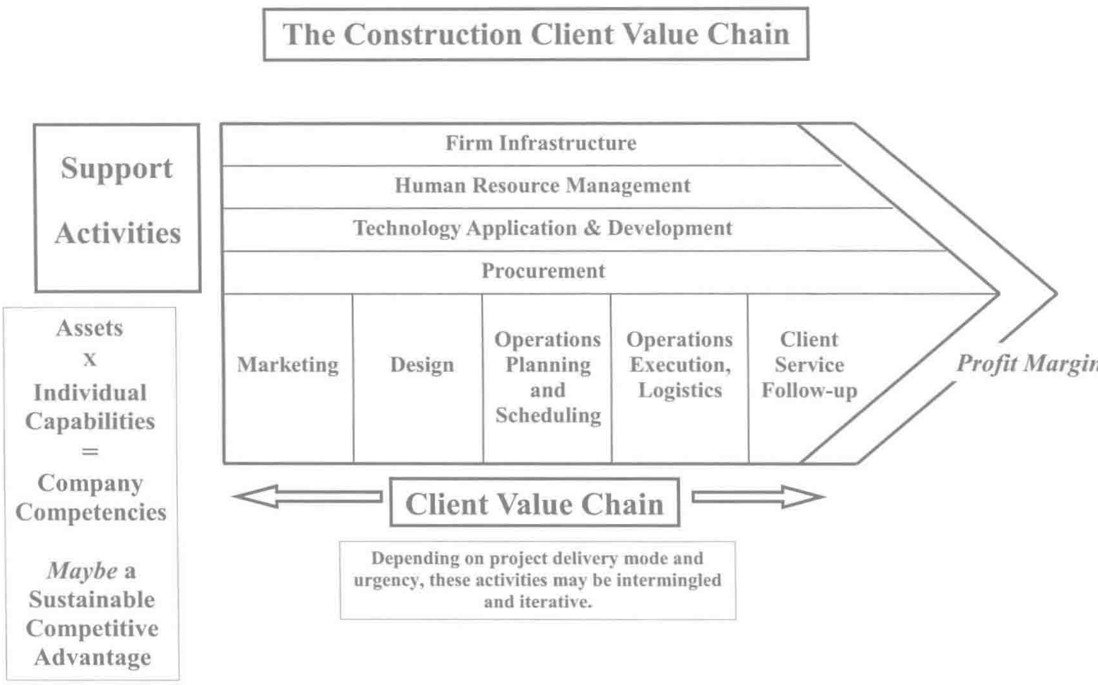

Figure 1-2. A generic construction industry value chain. Value is created for the client by project activities, but business unit or company-wide support functions can assist or hinder its creation. Activities on the jobsite affect and are affected by other people and functions of the firm. Site planning and logistics are links in the chain. Every company or business unit establishes its own value chain, which leverages its competencies in order to seek a sustainable competitive advantage and profitability (modified from Porter 1985, 37).

PROJECT SUPPORT ACTIVITIES

Skilled project professionals learn to leverage the supporting assets of their firms to ensure better performance at the construction site. A firm's support infrastructure comprises functions such as general management decision-making, finance and accounting, and legal expertise.

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These all-encompassing functions tend to affect the entire firm and most, if not all, of the value-generating activities of the company or business unit. If they are well done, the advantage accrues to projects of those firms compared to those of the enterprises that are not as administratively reliable. If not, then the enterprise may struggle even to justify their selection by an owner for a project.

Achieving necessary employee motivation and skills derives in great measure from human resources (HR) management. Although it is good organizational leadership that inspires employees to perform well, good HR policies help reduce frustration and discontent, which keeps skilled employees with a firm, thereby reducing turnover and enhancing efficiency.

Technology application and development are more than formal research and development (R&D) and tend to run through many offices and departments in contracting firms. Design divisions in some firms innovatively apply technologies. Other companies might establish automated linkages among cost estimating, field reporting, and cost accounting to administrative advantage. Building information modeling (BIM) is increasingly applied by the best builders. The methods and media by which documentation is prepared and ideas are communicated also are viewed as technological applications. Beyond management and administration, technology improves construction tools and equipment on-site to lend advantage to the contractors seeking higher, safer productivity.

Procurement support comprises all the policies and procedures by which supplies, materials, installed equipment, tools, and crew equipment are purchased for projects and internal purposes. Economic business relationships with vendors are important, but the procurement function is more than the act of ordering items from a supplier. It also includes the procurement of subcontractor and consultant services for the work of a project. Sources of competitive advantage for a contracting firm might include smart communication of procurement information among those with the need to input or know order and delivery status, retaining suppliers and vendors who cater in special ways to the company's needs, and being knowledgeable of the arcane rules and requirements of procurement for federal sector building construction projects subject to the Federal Acquisition Regulation (FAR).

Having the expertise of procurement professionals in a contracting firm can reduce waste and delay from wrong materials and quantities arriving on-site at the wrong time. Planning the packaging of materials to speed their installation and improve safety adds value, too. Of course, procurement can be no better than the timeliness and accuracy of requisitions submitted for materials and equipment. Contracting firms should include other facets of logistics, which are also part of operations execution and value creation in their procurement process. Chapter 6 explains sound site logistical procedures and administration.

THE FOUR PRIMARY PROJECT PERFORMANCE DIMENSIONS

Naturally, profit margin is a primary determinant of project success, but that measure of value is sometimes not known for certain until the project closes out. However, superintendents can more carefully evaluate their ongoing performance on the basis of safety experience, schedule control, budget adherence, and quality achievement. These performance indicators are measurable and essential for adjudging how well the building is being constructed. Section IV, Leadership and Control, provides necessary guidance.

Safety

Disciplined safety practices must permeate all planning for a construction project. The construction superintendent, assisted with the observations and expert advice of a company safety manager, is probably the single most important person to ensure that safe practices are known, implemented, and maintained throughout the project. The contractor's safety record for the previous three years of work determines the company's experience modification rate (EMR), which factors into the contractor's workers' compensation costs of labor and bidding costs. Some owners refuse to offer work to contractors with poor safety experience.

The contractor's supervisors must have safety enforcement authority commensurate with their duties. Wise contractors ensure that the Occupational Safety and Health Administration (OSHA) requirements are stipulated in subcontracts, because it gives contractual authority to site managers to enforce the required safety procedures.

Safety is truly a team effort and must be internalized by all. One sloppy or uninformed person can kill crewmates. In such an environment, dangerous work conditions are identified and communicated to workers and supervisors by anyone who sees them. When workers see that site supervisors never knowingly place people in risky work conditions and immediately remove everyone from such predicaments, if they unexpectedly do occur, their confidence in the leadership of the project to deal with safety issues grows. This devoted attitude of "safety first" is reinforced even by common logistical practices such as having heavy material packages delivered near the work face so they need not be carried far or toted across vehicle paths. Purchase orders (POs) to external sources, prepared from requisitions that cannot be satisfied within the company, can require that materials be bundled in ergonomic packages that reduce physical stress. The particulars of site safety management are summarized in chapter 10.

Schedule

Of time, cost, and quality, finishing the project on time is often the most prominent aspect of performance. While any facet of project performance can lead to dissatisfaction and, in the extreme, to the perception of project failure, one often hears or reads that timely completion is the most critical measure of acceptable construction project delivery. Chapter 11 presents task planning and scheduling techniques that effective superintendents routinely apply for larger and more complex works.

Cost

Strict cost control from the earliest stages of the project is essential to project completion within budget. In 2006 the author was told that of more than 800 U.S. government projects and programs including construction and required to apply a detailed cost-schedule management system, never did a project or program improve its cost status (budgeted vs. actual) after the work was 15% complete. Not one of them had better cost performance upon completion than what was reported at that point. Expecting that substantial early cost overruns can be recouped later in a project without affecting the schedule or quality is unrealistic. Any superintendent who is not extremely attentive to all costs and planning from project inception is asking for a budget overrun. Chapter 12 explains the principles of project cost control that building construction professionals should apply.

Quality

Quality in a construction project originates predominantly from the designer. The specifications and drawings, more than any other part of the building contract, convey the quality that is intended to be built into the work. The project is a team effort, however, and without disciplined contractor adherence to the contract requirements, suitable quality cannot be achieved. The best design and most careful specifications mean little if the contractor fails in its duty to understand the project documents and establish reliable means and methods to build the requisite quality.

Quality management has two aspects: quality control (QC) and quality assurance (QA). QC is the testing and checking of the work and its materials and installations to ensure that the contract specifications are achieved. Concrete cylinder strength breaks are an example of QC work. QA "checks the checker" by reviewing the systems, expertise, and conditions that affect the reliability and validity of the QC testing. Testing apparatus calibration, current laboratory certification, and updated training of the QC staff are QA actions, among others. QA often includes random checks of QC by performing, say, 5% extra tests to confirm the QC data, perhaps by employing a different laboratory.

More common in government work but increasingly required by private owners, a formal program of contractor quality control (CQC) contractually delegates responsibility for checking the work of the contractor. In these cases, the owner or its agent retains the duty of providing QA by establishing and recurrently vetting the systems and procedures that enable QC tests and techniques to remain consistent and accurate. Of course, good contractors check their work anyway, regardless of whether there is a formal CQC program. Rework is very costly. Chapter 13 relates techniques by which the contractor can deliver the specified quality to the owner.

DISCIPLINED PLANNING

"Failing to plan is planning to fail!"
—Alan Lakein, time management guru

To deliver success, a project team should plan activities or events with passion. One can find assorted "how-to" lists of planning steps. A simple one from AACE International is PDCA: **p**lan, **d**o, **c**heck, **a**djust . . . and repeat as necessary. Here is a more descriptive series of planning steps (Oglesby, 1989, p. 85):

1. **Plan the planning process**. Smaller efforts might almost be planned intuitively by experienced professionals, but the larger the operation, the greater must be the preliminary work to lay out the necessary steps and allocate the resources for a thorough, accurate, and coordinated plan. The leader of the team assigns specific tasks and deadlines to all who plan the project. The larger the building and the more self-sustaining the site, the more involved the preparation becomes. In their understandable haste to develop and execute a plan, inexperienced managers can overlook this critical step.
2. **Gather information**. Although effective bid development and cost-estimating processes focus attention on project planning, most of the detailed project planning

occurs after a bid is won and before the contractor mobilizes assets to the building site on or soon after the notice to proceed (NTP) date. The NTP is a letter that formally gives permission for the contractor to commence work. That time interval is sometimes called the "slump" or "slack" period (also see chapter 11). Project team members might be concurrently involved with work on other projects, but the PM and superintendent normally devote most of their time to planning the newly contracted job in earnest. Planning always seems to involve a judicious trade-off of time and effort against the reduction of risk and uncertainty about the work. Since time is never unlimited, uncertainty and risks may pervade the operational plan. A rule of thumb: 80% of the planning time should be devoted to the 20% of the project activities offering the most opportunity to develop efficiencies or mitigate risks. Selection of those activities hinges on professional judgment, which derives from construction experience.

3. **Prepare the plan**. Staffing decisions are very important to the project plan. Preparing the subcontracting and logistical plans is necessary for any well-managed work. While the logistical plan with its procurement plan section will vary from job to job, the procurement procedures (how requisitions and other recurring matters are processed) will be standardized. The first detailed project schedule is also a critical product of the planning that is frequently required before the owner's representative issues the contractor a NTP to the site or makes the first work progress payment. Well-run projects prepare contingency plans for risky developments. Detailed plans for some operations that occur later in the project, especially if it is fast-tracked, might not be developed until the later design stages; but as more knowledge about the work is gained after some of the on-site work is completed, details must be determined and instructions communicated to the field supervisors. Well-managed companies have standard operating procedures (SOPs) that require routine activities to be done in the same way on all the work they do. This saves decision-making deliberation time so that managers can focus on the planning requirements that are different for their project. SOPs also speed the performance of common tasks because the staff performs them uniformly and repetitively. For example, logistics procedures—not the project-specific logistics plans—are often standardized in a firm.
4. **Communicate the plan to those with a need to know**. Timely and correct implementation of project plans mandates prompt oral and written communication to all with a need to know and act. Even if future requirements are not definitely known, field supervisors should be aware of reasonably possible demands. Regularly planned meetings among field supervisors and staff are a part of good communication for project planning and supervision. Chapter 9 discusses good leadership communication techniques.
5. **Evaluate the results**. It is essential for good project management that measurable objectives be established so that the planned and actual performance can be compared. This enables managers to accurately modify future actions in order to improve results. Good supervisors discipline their decisions and instructions to seek continuous improvement of performance.

The following sections discuss some important topics that the construction project planner must address.

Geography

The geographical characteristics of a construction project site include the following:

1. **Topography**: The lay of the land can help or hinder on-site movement of materials. Terrain slopes, for example, can affect surface drainage.
2. **Accessibility, communication, and transportation**: Logistics is a major site-cost element for construction contractors. A long commute to the site, for example, tends to degrade worker productivity, and in some cases travel to the site may be paid by the project. Sites that are highly restricted in accessibility, movement, and storage space complicate planning and increase project cost (figure 1-1).
3. **Elevation**: Less oxygen at higher elevations can degrade the performance of people and equipment.
4. **Climate**: The general weather patterns at the site, including temperature and precipitation, can affect productivity, materials, equipment, and application techniques. The vegetation, soil types, and drainage patterns of the site may also be influenced by long-term climatic effects.
5. **Natural resources**: Project feasibility and construction methods can hinge on the proximity of necessary construction resources, such as suitable soils and water.
6. **Nearby business and residential development**: Nearby development can be a constraint or resource for the project. For example, if earthwork hauling operations are slowed by congested traffic, the project may become costlier. Conversely, having many nearby suppliers can ease logistical planning and responsiveness.
7. **Laws, regulations, and work rules**: These can vary widely from region to region. They affect administrative procedures, inspections, site overhead costs, and crew productivity.

Analysis of these matters underlies broad planning concerns. Many of the details that building professionals must know or do before working on-site, as a matter of due diligence, are reviewed in chapter 2.

Geology

Mother Nature is fickle. The geological features among construction sites can vary a great deal. The foundation and drainage conditions are very important geological characteristics that derive from the geological history of the site and occasionally are impacted by the historical activities of people. Although the specifics of every site will vary, knowledge of the area's geology can give the contractor a fair idea of the array of soil types and drainage challenges that might be confronted (Leggett & Karrow, 1983, p. 18-3).

Geological studies describe the underlying composition and structure of the earth throughout a region. They can show the contractor information that the site-specific soils report probably does not fully display. A series of two-inch diameter investigation boreholes sunk, perhaps, only at the corners and center of a large building footprint often misses some of the underlying materials or obstructions that can affect the work (see figure 1-3). As an example of subsurface risks, despite a competent site investigation, the excavation for a building foundation at an urban site uncovered asbestos containing materials (ACM), which delayed the work while the refuse was removed at added cost. Some cities maintain a public record of the past use of land, and this can offer good information about possible hazardous materials on sites.

Knowledge of the geology often enables better appreciation of the effects of construction operations on the soil and groundwater as well as their effects on the construction project. Usually, a soils report and, perhaps, a geological survey will accompany the bidding documents, which can provide the contractor the detailed information it needs for thorough planning. Owners have a duty to inform bidders of hidden ground conditions of which they are aware and which can be expected to affect the contractor's means and methods of work. Owner-provided information is often accompanied by a contractual disclaimer that the contractor should use the

Figure 1-3. A geotechnical investigation rig. The investigation is usually performed before the contractor is hired, as part of owner due diligence, and the results are published in a geotechnical or soils report, which could be part of the bidding documents. Soil samples can be extracted in driven sampler tubes for analysis. The results are displayed by boring logs, which commonly give the soil classifications, soil moisture contents, and penetration test blow counts at various depths. The log also shows the groundwater level, which might fluctuate over time to affect construction operations.

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