CHAPTER 29

CONSTRUCTION COST ESTIMATING

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INTRODUCTION

Development projects often begin with the developer or landowner approaching the land development team with a piece of property, and possibly a development program or intended use. The following economic or cost questions are likely to arise almost immediately and demand more precise answers as the project advances:

- Is the expense and effort involved worth the return, that is, is the site/project profitable?
- Can I complete the development in a reasonable amount of time?
- How much risk and potentially hidden cost does the development have?
- Is the project a good short-term investment? Long-term?
- Will people buy/rent/lease the product in a predictable period of time?
- Is adequate financing available to cover design and construction?

Construction cost estimates directly respond to some of these questions and facilitate finding the right answers to the others. Land development engineers are commonly requested to prepare cost estimates as part of the land development design process. The estimate's intended use largely determines the level of detail and the information required. In turn, the level of detail determines the time and, hence, the cost of preparing the estimate.

This chapter defines the possible purposes of estimates and identifies estimate types and their limitations. It is always important to state the assumptions that were made in the process of preparing the estimate. When preparing estimates with more detail, the importance of including all elements cannot be overstated. Therefore, we have provided a checklist of elements that should be included in the detailed estimate. Methods of estimating are identified, as well as sources of obtaining current information on construction costs.

Frequently the land development engineer is asked to compare the economic costs and benefits of several alternatives. For this reason, basic engineering economic theory and typical example problems are included.

PURPOSE OF COST ESTIMATES

Although cost estimates are prepared for both private- and public-sector projects, cost estimates for private land developers differ from those for public-sector clients in a very basic sense: construction cost estimates prepared for public projects, also called *capital projects*, are used to determine the economic benefit of the project based on public need, whereas cost estimates prepared for land development projects are used first by the entrepreneur to determine whether a project is economically feasible. The economic feasibility analysis combines the market analysis and the marketability study (performed by the developer/owner or qualified consultant) with development and construction costs garnered from feasibility analysis or preliminary design, debt structure, and the required rate of return, then tests the outcome in order to arrive at a go/no-go decision. For a small to midsize local or regional developer/builder, the decision is frequently based on the conjectures for the marketplace, the cost estimates provided by the consultants, and previous success with particular project types. In all development projects, location, timing, and cost control are the critical elements that must be evaluated carefully and consistently throughout the process in order to deliver a financially successful project.

Later, if the decision is made to proceed with development, a further refined cost estimate can be used to establish price points or selling prices of the product(s).

Public Project Cost Estimates

On a public project, three types of estimates are performed:

1. Preliminary cost estimates
2. Detailed cost estimates
3. Engineer's estimate or bid estimates

It is important for the land development engineer to understand the process by which a cost estimate for a public facility is prepared, since a publicly funded project is frequently an integral part of the overall land development venture.

The preliminary cost estimate for public projects is prepared prior to the development of detailed engineering plans and is used to solicit funding, generally from an annual capital improvement program, grants, or a voter referendum or bond issue. It is prepared with only a basic understanding of the general scope and extent of the project. Additional considerations are included, if known, such as special structures that are required; additional studies that may be warranted such as soil, wetland, or floodplain studies; land acquisition costs; and access considerations. The costs can be approximated using nationally published reference manuals (e.g., *RS Means*) or by using the local governing agency pricing guidelines. Often, costs from recently constructed projects of similar design are used as a source of cost data for such considerations. The accuracy of the preliminary cost estimate hinges upon the availability of accurate existing information and timely decisions regarding the details of the new development program. Generally, a significant contingency is included—as much as 30 percent—and frequently the cost of inflation is included since it may be several years before the project is actually constructed.

The detailed cost estimate is performed after the project is funded and designed. It is based on actual quantities estimated from the design plans. It is very similar to the detailed cost estimate for private projects, which is discussed in more detail later in this chapter. The detailed cost estimate should have an accuracy range of 10 to 15 percent.

The engineer's estimate or bid estimate is prepared as the project is awarded for construction. This estimate is very detailed and it should be as accurate as possible, within ±5 percent of the actual cost. It should be based on a thorough review of the plans and specifications, the solicitation of prices from suppliers and specialty contractors, and the most recent cost of construction of the specific elements of the plan.

Private Project Cost Estimates

For private land development projects the types of estimates are:

- Feasibility cost estimates
- Preliminary cost estimates
- Construction cost estimates

The feasibility estimate is used by the developer in making a go/no-go decision. The preliminary cost estimate is performed after a plan has evolved but before the preparation of actual construction drawings. It is used by the developer to secure funding and to assist in developing alternatives before a final decision on product details. The construction cost estimate is prepared to finalize loan commitment and to compare bids from contractors. Each of these types of estimates is defined further in the next section of this chapter.

In summary, while there are some similarities between public and private project cost estimates, the uses to which these are applied vary. The purpose of the cost estimate for a public facility is to justify and prioritize the project components as well as determine the economic benefit or need as weighed against the cost to the public. The private land development cost estimate provides the developer with the all-important part of the development process: the cost to construct and, consequently, the amount that must be charged to recover these costs and still achieve the desired profit.

TYPES OF ESTIMATES

As stated previously, there are three basic types of estimates used in the private land development process:

- Feasibility cost estimates
- Preliminary cost estimates
- Construction cost estimates

Although there may be refinements or variations, these three constitute the main types of estimates. Generally, as a project progresses from the conceptual stage through design to construction, these estimates come into play to enable basic decisions for the project to be made. The primary difference between the three estimates is the level of detail on which the estimate is based.

Feasibility Estimates

Land development engineers are frequently requested by the client to assist in determining the initial feasibility of a project. In this process the general procedure is to review such elements as availability of services (utility services and their easements, public services, schools), the potential yield in terms of number of units or square footage of commercial or office space, potential environmental impacts, and a host of other elements (boundary and topographical surveys, soil tests and bearing capacity, need for retaining walls and special structures), all of which can impact the developer's bottom line (profit).

Many of these elements involve substantial expenditures, both in terms of fixed and capital costs. If the project is constructed at a time of high interest rates or when loaned capital is scarce, a well-prepared, all-inclusive cost estimate for the planned project is essential. It can ensure that the project is worthwhile or it can result in a decision to abandon the project before the incurring of any additional cost, including the development of detailed plans. Investment decisions by both the developer and the lender rely heavily on these estimates.

As technology changes, the consideration of alternate ways of performing some of the basic construction processes can be important. Cost estimates of each alternative can influence the final mix of technologies employed in a project. While the engineering portion of a feasibility study can determine whether the project can be performed technically, the economic or cost feasibility portion of the study determines whether it makes sense for the project to proceed financially.

It is common knowledge that many projects, which in the final analysis have lost monetarily, have been the result of decisions based on incomplete studies, obsolete information, or optimistic rather than conservative assumptions. A good rule to follow when estimating costs is to err on the side of conservatism.

Many times cost feasibility studies can be used to identify a better economical use of the parcel of land. For example, in evaluating the different lot sizes that can be placed on a parcel of land, one may attempt to maximize development lot yield by minimizing lot size. However, a cost feasibility estimate can provide information to establish the true cost of the individual lots. The result could determine that the most profitable mix might not be the one that results in the most units.

The feasibility estimate is used for exactly the stated purpose, that is, to determine the economic feasibility of any given item. That item can be the entire project or, on a smaller scale, a variation of a particular roadway alignment, bike path, or water main extension. Feasibility estimates can be separated into two types: (1) rough, or ballpark, estimates and (2) detailed feasibility estimates.

Rough, or Ballpark, Estimates. Many times during the course of designing a land development project, an engineer is asked to give an informal estimate to determine whether a particular item under discussion should be pursued or given further study and design consideration. These informal estimates are called "off-the-cuff" or "seat-of-the-pants" estimates. Unfortunately, the terms can imply humor and that these estimates need not be accurate and, hence, can be done by anyone. In truth, only seasoned engineers familiar with land development applications should give ballpark estimates, as only years of varied experience can allow them to ascertain what should be included in such an estimate. In addition, only with experience can one look at the final answer and know whether it makes sense. It may be better if the land development engineer provides the quantities and allows the owner/developer to provide the unit cost numbers, unless the engineer has some current costing data on which to render the opinion or the engineer contacts local contractors for their input.

In any case, it is important that the engineer document, in a memorandum, the assumptions and methodology. That memorandum can be given to the owner/developer if appropriate or requested and should be placed in the project files as a permanent record.

These types of estimates are also called *order-of-magnitude* estimates. Generally, they have a low level of accuracy and can vary by as much as 25 to 50 percent. While accuracy is sacrificed in these types of estimates, they can be useful for evaluating a large number of alternatives in a short period of time. One must always document assumptions and be aware of the inherent limitations of this process.

This rough estimating procedure presumes an upper-end average cost for the significant items of the project. One might assume a certain dollar cost per linear foot for installation of storm sewer pipe, even though the cost would actually vary according to pipe size and depth. If, however, there is only a small amount of storm sewer on the project and this cost, relative to other items in the project, is insignificant, then it might not be included in the ballpark estimate. Items such as this are lumped together in the ±50 percent allowable error. This is where the experience level of the engineer is important in knowing what or what not to include in the analysis and knowing what upper-end average cost can be used.

Timing of the project is a significant consideration: many projects have fallen victim to financial disaster because of changing markets, the inherent effects on interest and carrying costs, fluctuating cost of money, rework of improperly designed or constructed features, and poor project management. The only solution is to identify, during the feasibility period, the greatest number of variables and learn as much as possible about their impacts on the project, then schedule and control the process in such a manner that, when the surprises come, they do not destroy the overall profitability of the project. For instance, the land development engineer might consider adding up to 5 to 7 percent of the cost estimate for a project with a shorter than usual construction period, for the design-build project, or for construction that will be adversely affected by the winter months.

The following example problem is intended to show how the rough estimating process can be used for a general large-scale project.

EXAMPLE 1

The owner/developer is considering a proffer to provide 20 percent of the construction cost for an elementary school as part of the residential development project. Before agreeing to this proffer, the owner/developer asks the engineer for an order-of-magnitude estimate of the cost.

In this example, the engineer decides to provide a ballpark or order-of-magnitude estimate by comparing the anticipated school with a recently completed school of similar nature. In doing some research, he finds a school was constructed two years ago in a neighboring jurisdiction for $8.5 million. He is aware that soil and terrain characteristics are similar for the two sites, but that the anticipated student population for the proposed school is one-half that of the reference school. He decides to compare the two schools based on a construction-cost-per-student basis. In other words, he assumes that the cost of a school for one-half the number of students would be 50 percent that of the reference school.

The engineer performs the following calculations:

1. Assume a 6 percent inflation rate per year in construction costs; therefore, the comparison school would cost $9.55 million today (two years of inflation at 6 percent.).

2. Assume for this estimate that a school serving half the number of students would cost 50 percent of the $9.55 million, or $4.78 million. The engineer decides to round this to $4.8 million.

3. Assume that the school will be constructed at the end of the development phasing of the project (five years from today). At an assumed inflation rate of 6 percent per year, the final cost, in five years, for the school is $6.42 million.

4. To allow for errors in the assumption that school cost is directly related to school population, and to recognize that the differences in site characteristics can influence the costs substantially, he assumes a 25 percent contingency. The cost for the new school is then estimated to be $6.42 million ± 25 percent, or a range of $4.8 to $8.0 million

5. The engineer provides the cost estimate of $4.8 to $8.0 million to the developer. Since the developer is considering offering 20 percent of the cost, he can consider a future obligation of between $964,000 and $1.6 million.

6. The engineer documents his assumptions and the source of his data in a memorandum to the owner/developer and a copy is kept in the project files.

To summarize, ballpark estimates should be understood to represent nothing more than rough approximations and are intended to be quick estimates. They can be refined when more accurate data is available. They can be an important part of any project development in that they enable quick evaluation of some topic without detailed design or cost estimating. They should be prepared or evaluated only by experienced personnel or at the minimum they should be checked by someone with considerable experience.

Too many times these ballpark estimates are taken to be exact, especially when they are underestimated. The contractor, developer, or other land design professional then wonders what went wrong. This is another reason to err on the conservative side.

Detailed Feasibility Estimates. A detailed feasibility estimate should be performed for all land development projects. Many times the feasibility estimate is part of a larger project feasibility study that evaluates availability of services, potential yields, and potential environmental impacts along with other important factors. If a ballpark estimate indicates a favorable economic condition, it is always desirable to pursue the development of a more detailed feasibility estimate. This type of estimate utilizes a far more refined estimate of quantities and costs associated with project construction and should incorporate all expenditures, including those for land and construction costs, infrastructure, and off-site construction. It is important that this estimate contain the costs for engineering design and surveying, legal fees, governmental review and permitting fees, and, if appropriate, the cost of borrowed capital.

This estimate is also called a *conceptual* or *budget estimate*, and should be accurate to within 15 to 20 percent of the actual cost. To perform this level of estimate, a preliminary layout of the project with streets, utilities, and lots is needed. Preliminary lots are needed to indicate whether the market price will offset the cost of the development construction costs and still yield a reasonable profit.

It is important to note that attaining additional yield does not always guarantee additional profit. Oftentimes the cost to develop the additional yield is offset by additional infrastructure requirements such as American with Disabilities Act (ADA) compliance, environmental mitigation, or other costs to extend streets and utilities. Example 2, later in this chapter, reinforces this concept.

Feasibility Checklist. In developing a cost estimate at this stage of the project, some design data is needed so that rough takeoffs of quantities can be performed. Some engineers include the cost estimate right on the development plan, so that as the plan changes and becomes more refined, the cost estimate can be updated as well.

Most engineering firms develop a feasibility checklist so that all items are considered even if some are not needed on the particular project. The checklist also makes it easy to compare estimates with other projects and ensures consistency when it comes to quality control/quality assurance checks common at each stage in the design process.

Generally, the following elements are to be included in a feasibility cost estimate:

- Land costs
- Clearing, grubbing, and demolition costs
- Roadway, sidewalk, trail and bike path costs
- Storm drain costs
- Sanitary sewer costs
- Water supply costs
- Other utility (power, gas, and communication) costs
- Lighting, traffic signals, and signage
- Grading and earthwork costs
- Erosion and sedimentation control costs
- Stormwater management system costs
- Landscaping costs
- Recreational facilities costs
- Off-site costs (special costs)
- Permits and bond costs
- Soils (rocks) and geotechnical fees

See the following sections describing each of these elements in detail.

As is evident, the development of a feasibility cost estimate can be time consuming. Care must be taken, however, to not overdetail the estimate at this early stage of design. Actual costs, of course, will not become known until the project design is completed. The estimation of project costs as completely and accurately as possible is essential to the client's decision-making process. The identification of *potential* costs is also critical to allow for alternative planning.

Preliminary Estimates

Preliminary estimates, sometimes referred to as *semidetailed estimates*, although considerably refined from the feasibility estimates, are still preliminary. They are developed from plans that have not yet reached sufficient detail to derive construction costs. These estimates should be accurate to within 10 to 15 percent.

These estimates are usually made after a plan has evolved to a fine-tuned stage but prior to actual preparation of final construction drawings. They can serve as advanced conceptual or advanced budget estimates and are usually accurate enough for making decisions regarding the feasibility of a project or for a decision involving a choice among alternatives within a project.

For preliminary estimates, the development plan or site plan should be drawn to scale, including the preliminary road and utility alignments and in some cases preliminary site grades. These plans can be used to estimate several important design quantities, which when multiplied by the applicable unit costs can provide a fairly good construction cost estimate.

After the preliminary development plans have been approved, detailed engineering and preparation of construction documents commence. There are costs associated with these procedures and they can vary greatly depending on the type of project and client (private or public). An estimate of how much it will cost to complete the final design should be prepared as part of the preliminary cost estimate in order to provide the client with an accurate idea of the project's cost to complete in terms of both design and construction.

A checklist should be prepared listing all cost items; the checklist for the preliminary estimates should be at least as inclusive as that employed for the detailed feasibility estimate. Since the quantities are still in a preliminary stage, a contingency factor of 15 to 20 percent should be added to the bottom-line subtotal, depending on the completeness and accuracy of the plans.

It is critical that the engineer and the client agree on the units of measure to be used for each of the elements included in the estimate. The units of measure may be obtained from a source such as the state department of transportation, department of public works, or any other public-sector entity engaged in construction or bond review/approval. Private projects may not always coincide with public specifications. The developer may require the units of measure in a certain format for loan application purposes or for analysis by the contractors; thus, it is important to have a mutual understanding of the cost estimate format.

The elements that should be included in the preliminary estimate are similar to those in the feasibility estimate, only they are based on the more complete plans. The elements to be included are described in the following subsections.

Land Costs. Land costs are usually expressed in dollars per acre and are provided by the owner. This is the line item within the estimate where the initial cost or price paid to the former owner for the parcel is accounted. Since the price is usually determined on an area basis, it is critical that a complete boundary survey be done to determine the exact parcel size. Boundary surveys are described in detail in Chapter 13. It is important to note here that the cost for the boundary survey is a land cost and should be included in the cost estimate.

To be complete, the cost of the deed, title insurance, and any transfer taxes should be included in the estimate. Real estate commissions are usually paid by the seller, but this should be verified, since they can be as high as 6 to 8 percent of the selling price.

Possible rezoning, special exceptions, and other amendments or planning processes that are required to permit the desired land use are another cost component under the land cost. For these actions, usually the new landowner's legal team fees and the cost of any studies (soils, Phase I ESA, etc.) and design fees through the entitlement approval are the main cost considerations.

Clearing, Grubbing, and Demolition Costs. Typically, the cost of clearing, grubbing, and demolition is usually a small portion of the total cost of construction. Most clearing quantities may be estimated on the basis of square yards or, for larger sites, even acres may be appropriate. Depending on the nature of the clearing/grubbing—light woods versus heavy forest versus developed areas such as parking lots—additional costs may be added. Soil remediation or removal to account for organic or other unsatisfactory material should also be accounted for under this item.

Where there are a number of structures to be removed, reused, or salvaged, a demolition plan is recommended in order to provide direction and clarity for the contractor. The cost of the demolition can be difficult to estimate because there may not be a history of unit costs from which to draw; there may be certain environmental regulations that require specific attention—for example, removal of asbestos, lead, or other identified hazardous and contaminated materials from the building or the site, consequently requiring a special subconsultant/estimator. Demolition of buildings should be estimated based on the number and sturdiness of the buildings to be demolished. A contractor expecting to be given the demolition contract may be willing to provide an estimate.

When estimating clearing, grubbing, and demolition costs, it is important for the engineer to have a thorough understanding of the proposed construction process in order to determine the applicable disposal scenarios: waste material may be hauled and disposed of in an appropriate landfill or it may be diverted, salvaged, or recycled on- or off-site. The disposal scenario affects prices assigned to haul routes, landfill tipping fees, and on-site sorting, storage, and treatment of materials. For projects where green building certification is desired, waste management is one of the metrics; a waste management plan addressing the disposal scenarios should be scoped and developed by an experienced professional in order to accurately determine and effectively manage costs in this category.

Roadway, Sidewalk, Trail, and Bike Path Costs. Costs are usually expressed in dollars per linear foot for roads, streets, alleys, sidewalks, trails, and bikeways/multiuse paths, and a lump-sum or square-yard cost for parking lots. This can be misleading, since there could be many separate items included in a linear foot unit cost, including earthwork, pavement, aggregate for the base and subbase course, curb and gutter, and underdrains, along with general street landscaping and sodding. In addition, if appropriate, the costs associated with street and lot lighting, street trees and landscaping, and signs and signals should be included if they are not accounted for as separate items. It should be emphasized that one of the objectives of road design is to obtain an earthwork balance of both the road and the entire site. Without an earthwork balance, the entire project costs can increase significantly.

Pavement costs are usually expressed in dollars per ton of asphalt pavement or per square yard per inch of depth for concrete pavement, and either cost is usually a considerable portion of the roadway cost. For this reason, the development engineer is expected to minimize these costs through innovative design. The traffic count or anticipated traffic load dictate the street width and pavement design. It is important to verify the sidewalk requirements of the jurisdiction early in the design process. Sidewalks both have an economic impact and impose a limitation on lot design. Please note that sometimes sidewalk requirements vary by lot size and street classification. Sidewalk costs can be reduced through judicious use of lot sizes and street types. In some cases, less expensive bikeways/multiuse paths and trails can substitute for sidewalks, but the engineer must be assured that they will be approved by the jurisdiction.

Storm Drain Costs. Storm drain costs are usually expressed in dollars per linear foot of constructed pipe or on a per-structure basis for items such as inlets, manholes, and junction boxes. Quantities for storm drain items including inlet and outlet structures as well as conveyance items (pipes, swales, ditches) should be derived directly from the preliminary plan.

Included in this cost is the pipe itself, culverts, inlets, manholes, headwalls, endwalls or end sections, riprap or other outlet protection devices such as plunge pools or energy dissipators, special drainage structures, underdrains, box culverts, additional vertical depth (excavation and structure sections), rock excavation, and special pipe bedding if needed. Additional costs can encompass backfilling and any site restoration costs, including seeding or sodding if the pipe is placed outside the roadway section. Costs of storm drains can be reduced through implementation of low-impact development (LID) techniques including provisions for porous pavement or other infiltration facilities, when feasible, especially for parking lots; use of natural channels/swales; utilizing the minimum adequate pipe size; using the least number of drainage structures; and setting pipe depths as shallow as possible.

If the proposed storm drain crosses existing utilities, which is common in developed areas, the vertical locations must be thoroughly investigated to ensure system compatibility. If there is a conflict in vertical locations, redesign and/or relocation efforts must be scoped and included in the cost estimate as early as possible. Utility relocation fees are usually substantial; thus, they should be identified during the planning and design process to be estimated accurately.

Sanitary Sewer Costs. Sanitary sewer costs are usually expressed in dollars per linear foot. In some cases a land development project may require a sewage treatment facility or an existing facility may require enhancements due to the construction of the project. To accommodate future development, it may be necessary to install a sewer main with a capacity exceeding the need of your subdivision. In cases when excess capacity is required, the responsible agency should participate in the cost sharing.

The basic sanitary sewer costs include the piping, laterals to the property line (house connections), manholes, drop connections, ejection pumps, and special structures. Restoration costs such as seeding and/or sodding should be included if the pipe is placed outside the roadway section. As with storm drains, costs for sanitary sewers can be reduced by keeping pipe lengths and sizes to the minimum, locating the trenches at shallow depths, and minimizing the number of structures. Additional cost items include rock excavation, roadway crossings, additional vertical depth (excavation and structure section), and jacking/boring/tunneling. Existing utility crossings must be considered and accounted for as previously described under "Storm Drain Costs."

Recently, emerging green building techniques have encouraged the on-site treatment and reuse of gray/blackwater, thus reducing the number of conventional sanitary sewer and sewerage treatment facilities required. While the conventional costs including impact or tap fees may be removed/avoided, it is equally important to accurately cost the new technologies implemented to treat and reuse the wastewater; costing a sustainable, or green, building sanitary treatment/reuse system requires the engineer to work cooperatively with the MEP engineer to account for all components and ensure the costs are assessed either on the site or in the building and not double counted. Regardless of the design approach to sanitary sewer—conventional or sustainable—the design must be code compliant and accounted for in the estimate. Depending on the technology, manufacturer input is likely the best source for unit price information.

Water Supply Costs. If the water supply company will be installing the water systems, the cost of providing water services should be based on their estimates. If the responsibility for the design and construction of the water supply and distribution system is with the engineering consultant, an estimate must be developed. As with sanitary sewers, costs for water distribution systems are expressed in dollars per linear foot. If a water supply and treatment facility, such as a well, a package plant, or a special pumping facility is needed, it is recommended that the land development engineer utilize the services of an engineer experienced in this specialty to provide the cost estimate. Other items included in the water distribution costs are valves, hydrants, water service line, fire lines, blow off and air releasers, tees, and pumps. Cost minimization methods are similar to those for storm drains and sanitary sewer design, and the elements included in the estimate are pipes, laterals services, fittings, water meters, thrust blocks and anchors, and special structures such as valve vaults. Tap fees should also be accounted for in this cost item.

Other Utility (Power, Gas, and Communication) Costs. Other utility costs such as gas mains, fuel transmission pipelines, electric supply, telephone, fiberoptic, and cable television should be included. There may be a requirement that overhead power and communication lines be relocated underground, thus requiring a conduit system. There may also be a need for equipment such as transformers and substations, which may increase cost and require easement provisions. Some utility companies pay for the installation of their utilities (set transformers and pull cables); some look for the developer to pay costs either entirely or on a prorated basis, depending on the foreseeable development in the community. Given the great variation in practice among different utility providers, the first step in cost estimating this item is to determine design/construction responsibility; often the developer is responsible for design and construction of the pathway (i.e., conduit systems), subject to the utilities' approval and base and aesthetic features such as concrete pads, landscaping, fencing, or other screening devices. Conduit is typically priced on a linear-foot basis, while structures in the conveyance system are priced as "each" or per structure.

The utility companies themselves, which may be either public or private companies, can best supply the cost estimates for their facilities. An estimate should be included for these facilities if feasible. Crossing these existing utilities is typically easily accommodated, since the cover requirements, horizontal, and vertical offsets for these utilities are fairly flexible, as they are not gravity driven. Regardless, relocation costs for other utilities should be examined and accounted for, especially when conduit systems are moved from overhead to underground installations.

Lighting, Traffic Signals, and Signage Costs. The cost of installing traffic signals, signing, lighting, guardrail, striping, and other traffic markings should be included. An estimate of the number needed should be based on the type of features and placement required by the jurisdiction. Lights and traffic signals are typically priced on a per-unit basis, while the associated conduits and wires in between the units are estimated on a linear-foot basis. Signage may be priced by square foot, square yard, or in some jurisdictions on a per-unit basis. Guardrail and striping are linear-foot quantities. Traffic signals and their related equipment should be priced by either a signal contractor or an experienced traffic engineer.

Grading and Earthwork Costs. Earthwork costs for the various infrastructure elements are usually included in the per-foot cost of these elements; however, earthwork costs for things such as mass, rough, and final grading of the streets and lots should be estimated separately. The cost of grading for streets and building pads is based on cutting/filling to the desired elevation and compacting the soil to the specifications of the soils engineer. The cost of grading building pads is charged at a different rate than the rate for grading streets and parking lots, so it should be listed separately on the cost estimate. They are usually expressed in dollars per cubic yard and include cut, fill, topsoil, borrow, and excess (earth hauled off the site). Engineers are directed to Chapter 23 for discussion of the importance of attempting to balance the earthwork on the site.

Earthwork costs can be significant, and earthwork engineering is often not readily understood by developers. Care must be taken during design so that, if possible, phasing of construction can be implemented to construct first in areas of cut so that earth can be moved to areas of fill without a secondary storage step or, in the worst case, earth moved off-site only to be brought back later for fill. Also, accommodations should be made if rock or ground water is shallow on the site. The engineer may consider raising the grade of the proposed site to eliminate the need to rip or blast through rock and may need to include provisions for dewatering, ground water diversion, or soil drying. Earthwork costs at this stage of plan development should be based on the most accurate earthwork model available (see Chapter 23 for earthwork methodologies).

Erosion and Sedimentation (E&S) Control Costs. Cost elements include sediment traps and basins, straw and maintenance bales, silt and super silt fence, berms, gravel for truck wash facilities, inlet protection devices, riprap, dewatering and pumping facilities, seed and sod, and erosion control matting. Similar to other elements of design, proper phasing of construction activities can minimize the cost of these facilities. Many jurisdictions require these items to be bonded similar to other public infrastructure components because of the environmental and aesthetic importance of proper erosion and sediment controls. Thus, in addition to the actual construction cost of these facilities, a further bond amount may need to be included in the estimate. Typically, costs to prevent erosion and implement sedimentation control run up to 3 percent of the total construction cost.

Stormwater Management System Costs. Similar to erosion control, jurisdictions are adopting more stringent stormwater management system requirements. In some cases these systems can equal or exceed the costs of the storm drainage system. Included in this item are the costs for both water quality and quantity control facilities. Given the wide range of facility types from natural systems including detention and retention ponds, bioretention gardens/basins, and infiltration trenches to manufactured or technology-based systems such as sand filters, oil/grit separators, and filter inserts, pricing these facilities is highly specific and difficult to generalize.

Natural systems must be priced to include excavation, grading, and embankment construction as well as spillway and outlet structures, inlet and outlet protection, underdrains and dewatering devices, landscaping, and access provisions including roads, paths, fencing, gates, and signage. Most of these items are unit quantities; however, there is a wide range of data available for cost estimating specific SWM facility types (bioretention, infiltration trenches, wet ponds, etc.) on a cubic-yard, square-yard, or acre-foot basis. When it is jurisdictional or client preference to estimate in this manner, the unit prices should be verified, if possible, with contractors experienced in the construction of these types of facilities.

The costs for manufactured systems are best garnered directly from the vendor; the engineer should inquire about the system cost and delivery and installation costs. Costs for additional or supplemental features such as manholes, inlets, underdrain, signage, and maintenance access provisions may still need to be estimated separately.

During the design of the project, system costs can be minimized by carefully placing facilities where they can serve both as a stormwater management facility and as a site amenity. Often a combination of devices is necessary to meet applicable requirements, and it is the responsibility of the engineer to optimize these features, given the goals and intents of the development program, as well as the cost of the various facilities.

Landscaping Costs. Cost estimating in landscaping applications is best approached by breaking down the landscape plan into components such as shade trees, ornamental trees, shrubs, perennials, annuals, ground covers, sod, seeding, and mulch. Other landscape architecture elements that are commonly coordinated with landscape plans include hardscape and architectural items such as gravel, brick and concrete paving, fencing, custom signage, and lighting.

Most plant material, including trees, shrubs, perennials, and annuals, is measured on a per-unit basis. Seeding applications are typically estimated based on an area of coverage and/or the specified application rate. Hardscape, including pavers (brick, concrete, or asphalt), is estimated based on area—typically in square feet or square yards, depending on the application. Fences are measured in linear feet, and retaining walls or other decorative walls are usually included based on square face footage. Topsoil, mulch, and other soil products are volume based quantities—cubic feet or yards. Specialty aesthetic features such as signage and lighting can vary greatly depending on the specific application and quantity and may be measured per unit or, often, as a lump sum for the installation. Quantities can usually be determined from the plant schedule and details and/or the preliminary plan. To ensure accuracy, quantities should be reviewed after construction documents are prepared.

RSMeans Landscape Cost Data and *RSMeans—Site Work & Landscape Cost Data* are examples of the widely accepted industry publications that price landscape work items and associated costs. In addition to the proposed construction items, the cost estimate may need to include a cost for existing plant material to be maintained and any special treatment associated with the preservation effort (trimming, aeration, etc.) as well as repairs to any landscape items damaged during construction or that die off during the warranty period.

Recreational Facilities Costs. Many times the development of a project includes the cost of recreational facilities. These may be proposed by the developer to enhance the project's vitality or in an attempt to seek support for approval of the development. In addition, the approving jurisdiction may impose additional recreational facilities during the entitlement process. These facilities may serve only the proposed development or additional users outside the project. For example, the jurisdiction might require the dedication of land for a regional park and require the developer to construct a pond as his or her commitment. The jurisdiction could construct the park features such as trails and buildings, and provide for future maintenance as the public commitment to the park's development. In this example, the pond could serve as the stormwater detention facility for the project and a recreational facility for the jurisdiction. As part of the cost-estimating process, only the developer's costs should be included in the cost estimate. A well-planned development could take advantage of these features through good initial planning and design.

Elements that should be included in the recreational facility costs are park development; sod and/or seeding; earthwork such as mounding, tennis courts, swimming pools, basketball facilities, fencing, and tot lots; and any landscaping elements not previously included. If there is an excess of earthwork in the project, good landscape design, through the creation of sound berms and mounds in the park, can reduce the costs of hauling away excess and unsuitable material. On the other hand, if there were a shortage of fill material, sound landscape design would consider lowering the future park site.

Off-Site Costs (Special Costs). To serve the development with adequate utilities or to adequately direct sewage or stormwater away from the site, many off-site costs can be required of the developer. Good engineering design should identify the condition of downstream outfalls and determine any requisite improvements required to these systems. Many times these enhancements are the responsibility of the developer and should be included in the estimated cost of the project. Care must be used not to prematurely state that these are 100 percent the responsibility of the project development. In some instances, the case can be made that these benefit adjacent future development or the public in general, and therefore, the costs should be shared. At this stage in the development, the engineer preparing the cost estimate can make an assumption and use this assumption in the calculation, but footnotes should be made to identify the assumption and a brief justification of the assumption.

Special or off-site costs that should be considered are those for streets and/or street widening and reconstruction, traffic controls, signalization, bridges, sidewalks, hike/bike trails, stormwater management facilities (in particular, regional facilities), landscaping, lighting, and signs.

Permit and Bond Costs. On most projects, permits from the local, and sometimes the state, governments must be obtained before construction can commence. Tap or hook-up fees are common for most utilities and should be included under this item if not accounted for under the individual utility costs. Many kinds of construction activities require inspections both during and after construction that are intended to provide consistency in construction activities and to provide for safety during both construction and in system use.

The permits associated with developing a tract of land can be numerous. The cost associated with procuring the vast number of permits must be accounted for. Permits are usually required for grading, paving, drainage, sewer connections, water connections, electrical and gas connections, wetlands delineation and encroachment, and forest or tree stand delineation, clearing, and impacts. The local and state governments could require additional permits based on regional considerations. Generally, the fees charged by the reviewing agency are structured to recover their costs for review of plans and inspection, but some governments use these fees as a way of securing additional general revenue. In any case, it is the responsibility of the engineer to carefully identify all fees for the required permits, since these fees and permits can be in the range of 20 to 25 percent of the physical construction costs for the project (excluding land acquisition and house construction costs).

On most projects of substantial size, the developer and/or contractor must post a surety bond and in some cases a conservation bond (covering erosion and sediment control, landscaping, and other natural site features to be installed or protected) to ensure adequate construction quality. While this bond is returned at the end of the project, it can involve a loan from a bonding company or, at a minimum, involve lost interest for the construction period. Many jurisdictions now permit the potential partial release of bonds as project phases are completed. Although this does not affect cost estimates, it can substantially reduce the developer's cost, and if the engineer can identify this possibility and move promptly to get the partial bond release, the client can save in terms of lost interest cost.

Professional Fees. As part of any project, professional consultant fees should be included in any cost estimate, since they can represent as much as 15 percent of the project cost. These fees include the engineer's, surveyor's, geotechnical, environmental consultant's, construction manager's, and architect's fees, as well as attorney expenses. Generally these fees are based on the cost of the facilities, factored by the complexity of the project. Attorney fees vary widely from a lump sum for the entire project to an hourly fee. Whatever method is chosen to estimate the cost, the assumptions should be clearly stated in the report that accompanies the estimate.

The engineering and architectural fees can be divided into two categories: (1) design development (usually up to and including the entitlement process, surveying, planning efforts, and preliminary engineering) and (2) final design and construction document preparation and permitting services. Construction phase services are typically an add-on or separate category and should be identified as such in the cost estimate. Typically, professional fees vary between 7 and 15 percent of the total project cost.

Financial Fees. Financial fees in the cost estimate are best left for the client to estimate, based on his or her particular situation. Financial fees are usually based on a percentage of borrowed money. Interest charges during the life of the project can be substantial if the project has a long history from purchase of land to completion of construction. The cost of financing may range from 5 to 20 percent of the total project cost.

Contingency Allowance. Allowing for contingencies is an elemental part of the estimate of project cost to allow for unforeseen conditions and for variances in design elements. There is no generally accepted percentage. The amount varies by the complexity of the project, the anticipated time for completion, and the individual idiosyncrasies of the engineer (i.e., conservative versus liberal). It is common to see contingencies used from 5 to 30 percent. If the engineer is unsure of the contingency to allow, it is recommended that a minimum of 15 percent be utilized. If the client disagrees, the amount can be altered by the client. However, it is recommended that the engineer's original contingency used by the engineer be documented in the project files. If the project is to be phased over numerous years, the cost of escalation should affect the contingency; alternatively, a separate line item can be included for inflation.

The notes to the cost estimate are particularly important. Any assumptions used in making the estimate should be clearly explained, including indication of whether the costs used are at current value or include an inflation factor.

Other Miscellaneous Costs. Other miscellaneous costs should be included if pertinent. Consideration should be given to such items as marketing analysis, maintenance cost of project elements constructed but not accepted by the operating agency until later, and other costs not accounted for in any previous section. These might include such items as environmental mitigation and special landscaping costs.

The engineer should elaborate on the possible costs that are not included, such as sound walls, environmental impact reports, and soil reports. Where the facilities required are oversized, the jurisdiction may give partial reimbursement to the developer for improvements larger than what are needed to serve the project. When this is the case, the anticipated reimbursement should be described. Costs that constitute refundable deposits, such as are sometimes required for water meters until the building is occupied, should be listed. Other costs include meeting current fire safety codes; providing handicapped access (current ADA requirements); other building code requirements retroactively required for existing buildings as part of the development subject to reconstruction/remodeling; making temporary vehicle, bicycle, and pedestrian access modifications to accommodate construction activities; and making parking modifications required to accommodate the contractor during construction. Restricted site access, limited material storage space, and a remote location certainly add to the cost of a project. For those projects that require an archeological survey, an additional fee of up to 1 percent may be needed to cover these costs.

Soils (Rocks) and Geotechnical Fees

The types of soils found on the project site can affect project construction costs because of the need to change the existing soil characteristics. If a significant portion of the soils cannot be made compatible with the proposed development program, the costs for replacing the existing soils can be extreme. Excavation and the provision of sufficient suitable backfill can also increase costs.

The presence of rock on the proposed site will also have a tremendous effect on the construction cost. If excavation of rock is required, blasting may be necessary.

Summary. The purpose of preliminary engineering is to acquire approvals from the permitting jurisdiction to determine the problems that will affect the project and the cost to construct it. Among other uses, preliminary estimates are valuable for obtaining developer loan applications, developing cash flow schedules, and fine-tuning preliminary market prices for product.

These costs may (and should) be estimated again throughout the design process, but it is imperative to be thorough from the beginning, as the economic success of a project is often closely tied to the preliminary cost estimates.

Construction Estimates

Construction cost estimates, also referred to as *detailed estimates*, are generally developed only after the construction plans have been approved by all necessary agencies. Quantity takeoffs for work to be performed are often made before all final approvals are obtained. Therefore, it is critical that all takeoffs and estimates be dated and referenced to a dated plan sheet. This ensures that the final construction cost estimate is based on the final approved plans used for construction.

Construction cost estimates can be performed by different professionals, but, as is always the case, should be reviewed and approved only by persons with many years of experience to ensure the thoroughness and credibility of the estimate. It is important that somewhere in the process an individual with knowledge of the details of construction work perform a constructibility review and either develops the estimate or checks the efforts of others. This knowledge is best acquired through actual experience in construction work. It is also important for the estimator to be able to visualize the various construction phases of a project and incorporate equipment needs, materials needed, and the handling of these during construction.

It is important during the development of the construction cost estimates that the latest available information be used. An experienced engineer should keep an updated file with recent bid information on materials, labor, and the availability of construction items. Later in this chapter, a list of possible sources for this information is provided. The developer and design engineer need to be wary of potentially outdated data. This can include infrastructure record drawings on file with public entities for the project's location, previous surveys, aged geotechnical reports, and aged cost data for previous similar projects. The design engineer should make recommendations to the developer regarding the need to obtain more up-to-date information. Some of the information can be verified through new surveys and site visits. Other information about such things as types and quantity of soil and rock, fiberoptic cables, and gas lines can be more difficult or costly to verify because there are few surface clues to be found. Even if these are updated, the percentage of contingency should be reviewed based on the comfort of the developer and design team with the procured information.

In general, the construction estimate should include the quantities and unit costs of all items needed to construct the project. The construction cost estimate can be used for some of the same items as identified for the preliminary estimate, such as loan applications, cash flows, and the development of market prices. In addition, this estimate can provide the owner/developer with a reasonably accurate guide for the amount of funding needed to complete the project.

After the plans are complete, exact measurement of construction materials can be made. The lengths of curbs, areas of roadways and landscape, tons of asphalt, and all the materials and activities needed to construct the project are now known and can be shared among the design team to verify preliminary estimates prior to bidding or release of construction documents. Contractors will also make an estimate and determine what their costs of construction will be before they bid on the project. If the engineers' and the contractor's estimates are very different, the reason should be understood. A poor economy may prompt contractors to bid low because of the need for work, but the developer should be leery of contractors whose bids are very low—that is likely to indicate a poor understanding of the work involved. If contractors' bids come in high, the developer may want to seek out more contractors to bid on the project or ensure the design team has not made an error(s) in their estimate. Sometimes sharp price fluctuations (e.g., of steel or crude oil) may significantly affect the unit price of items such as structural steel, reinforcement, and asphalt.

Many times the developer will ask contractors for bids on selected portions of the project, including infrastructure, grading, and roadway/street construction. The construction cost estimate should be formatted so that the data needed to compare actual bid prices with the estimate is easily obtainable. Wide disparities in the bids, if several bids are being compared, usually indicate a lack of clarity in the plans, specifications, or instructions to the bidder. One or two marked deviations from all the bids, however, usually indicates some oversight or lack of understanding by the bidder.

The construction cost estimate should be accurate within 5 to 10 percent. The accuracy depends on the complexity of the plans and specifications and on how current the bid data used to develop the unit costs is. Errors in the design plans can greatly affect the accuracy of the cost estimate. Backcharges and extras by contractors due to incomplete and/or inaccurate plans increase costs significantly.

Since construction cost estimates utilize quantity takeoffs from drawings to be used in constructing the project, the cost estimate is obviously only as accurate as the quantities to which costs are assigned and the accuracy of the estimated cost. In addition, the engineer must recognize that multiplication of numbers, as performed when applying unit cost to quantities, can result in magnification of errors. Propagation of errors in the product of two independent variables, where A and B are the independent variables and ε is the uncertainty or error in the variables, is shown in Equation 29.1.

$$C \pm \varepsilon_C = (A \times B)\sqrt{(A \pm \varepsilon_B)^2 + (B \pm \varepsilon_A)^2} \qquad (29.1)$$

For example, suppose the estimate for excavation is 10,000 CY ± 20% and the cost is \$10.80 ± 10%. Using Equation 29.1, the accuracy of the cost is:

$$\begin{aligned}
&(10{,}000 \pm 20\%) \times (\$10.80 \pm 10\%) \qquad (29.2)\\
&= (10{,}000 \pm 2{,}000) \times (\$10.80 \pm \$1.08)\\
&= (10{,}000 \times 10.80) \pm \sqrt{(10{,}000\,(1.08))^2 + (10.70\,(2{,}000))^2}\\
&= 108{,}000 \pm 24{,}150\\
&= \$108{,}000 \pm 22.4\%
\end{aligned}$$

Note that although the estimated range (i.e., error) in quantity is 20 percent and the estimated range (i.e., error) in the cost is 10 percent, the overall accrued error is 22.4 percent.

When two independent variables are added together, the accrued error is represented by Equation 29.3.

$$C \pm \varepsilon_C = (A + B) \pm \sqrt{\varepsilon_A^2 + \varepsilon_B^2} \qquad (29.3)$$

Table 29.1, generated from Equation 29.1, provides the expected error, given the errors of the two independent variables. For example, the error of 22.4 percent calculated using Equation 29.2 can be obtained by entering 20 percent for variable A and reading across to the 10 percent column of variable B. Table 29.2 shows how errors are accrued when numbers are multiplied and added together. Care must be used to minimize the errors; otherwise, they can be compounded throughout the estimate.

It is imperative that every item indicated in the construction plans be included in the estimate, since the contractor installing these items will most surely include it. It is especially important for the construction cost estimate to try and give at least a guesstimate of contingent items such as rock excavation, pipe bedding, excavation, and removal of unsuitable material, undercutting, and other similar items. These items need to be recognized initially should they become necessary in the actual construction they have been planned for, although they were not specifically indicated on the construction drawings. When such guesstimates are included, it is recommended that they be footnoted to differentiate them from the normally more accurate cost items.

It is recommended that engineers utilize a standard checklist and a statement cost estimate sheet or develop ones if they do not exist. Existing computer programs for data manipulation work well to standardize the form and can perform all arithmetic functions automatically. When computerized, they can be the basis of a method of filing historic costs. A typical checklist is shown in Figure 29.1. A standard cost estimate sheet is shown in Figure 29.2.

For construction cost estimates, a contingency of 10 percent is usually employed, depending on the source and timeliness of the unit costing.

TABLE 29.1 Percent Error Expected in the Product of Two Independent Variables

% Error in Variable A	Percent Error in Variable B: 0	5	10	15	20	25	30
0	5	5.0	10.0	15.0	20.0	25.0	30.0
5	5	7.1	11.2	15.8	20.6	25.5	30.4
10	10	11.2	14.1	18.0	22.4	27.0	31.6
15	15	15.8	18.0	21.2	25.0	29.2	33.6
20	20	20.6	22.4	25.0	28.3	32.1	36.1
25	25	25.5	27.0	29.2	32.1	35.4	39.1
30	30	30.4	31.6	33.6	36.1	39.1	42.5

TABLE 29.2 Compounding of Errors Showing Quantities Times Unit Costs

Item	Quantity	Unit Cost	Total Cost	Accuracy ($)	Accuracy (%)
Excavation	10,000 CY ± 20%	$10.80 ± 10%	$108,000	$24,150	±22%
Concrete sidewalk	250 LF ± 15%	$40.00 ± 20%	$10,000	$2,500	±25%
36-inch-diameter concrete pipe	320 LF ± 10%	$90.00 ± 15%	$28,800	$5,192	±18%
			$146,800	$31,842	±21.7%

Table 29.3 shows a procedure list as used by a typical land development engineering group. It is intended to provide a framework for proceeding through the preparation of a cost estimate. Not all items will be needed for every estimate; however, all should be considered.

VARIABLES AFFECTING COST

Many variables affect the cost of a project. As the engineer is preparing the cost estimate, he or she should be aware of whether any of the following items are significant enough to be investigated in more detail: size of the job, location of the site, season, current state of the economy, financial factors, cost of the property, type of the zoning and use, whether any utility or road relocation is involved, whether any unusual structures (e.g., retaining walls, bridges) are involved, and an inflation factor.

Size and Complexity of the Project

The size and complexity of the project can have a significant effect on the cost of physical improvements, particularly when considered on a cost-per-unit basis. Smaller sites can require a nonproportional cost for infrastructure improvement, particularly with respect to streets and underground utilities. Quantity discounts that are given for construction materials may not apply for smaller sites. Furthermore, it is important to note that attaining additional yield—for example, more housing units—does not always guarantee additional profit. This is especially true if the cost to develop the additional yield is offset by additional infrastructure costs. The following example demonstrates that this condition could occur.

EXAMPLE 2

After a 60-unit single-family development project is into the design stage, the client (developer) considers an offer to purchase an adjacent site to add to the total project. The site would add 12 units and, due to its location, would enhance the attractiveness of the project. However, the parcel of land being considered has steep terrain and must be elevated by fill. To accommodate the additional units, the sanitary sewer and storm drain system for a portion of the initial site (Phase I) must be constructed deeper for 25 percent of the units, at an additional cost of $2000 per unit. How should you as the developer's engineer, analyze the situation and what advice should you give your client?

SUBDIVISION NAME ______________________________

(Section, Lot No.)

Contract/Work Order No. ______________________ **Date** ______________

____

Signature

***All cost estimates shall be prepared by a <u>senior engineer</u> who will include all the following items in the cost estimate. (If not, briefly describe why!)

1. ______ **Clearing and grubbing**

2. ______ **Excavation:**
   - a. ______ Class A, Rock excavation
   - b. ______ Class B, Regular
   - c. ______ Class C, Wet
   - d. ______ Class D, Haul
   - e. ______ Class E, Borrow
   - f. ______ Class F, Shrinkage

3. ______ **Sheeting and shoring**

4. ______ **Utility lines**
   - a. ______ Sanitary sewer lines
   - b. ______ Storm sewer lines
   - c. ______ Underdrains
   - d. ______ Waterlines
   - e. ______ Electric
   - f. ______ Gas
   - g. ______ Lighting
   - h. ______ Remove and replace pavement

5. ______ **Utility lines should be estimated considering the following:**
   - a. ______ Depth of excavation
   - b. ______ Gravel underdrains
   - c. ______ Size and classification of main
   - d. ______ Linear foot quantities
   - e. ______ French underdrains
   - f. ______ Sheeting and shoring
   - g. ______ Hand excavation
   - h. ______ Rock excavation
   - i. ______ Wet excavation

6. ______ **Concrete work**
   - a. ______ Curb and gutter work
   - b. ______ Sidewalks
   - c. ______ Wingwalls
   - d. ______ Cut-off walls
   - e. ______ Riprap
   - f. ______ Reinforced concrete
   - g. ______ Miscellaneous concrete work
   - h. ______ Retaining walls

7. ______ **Pavement**
   - a. ______ Subbase
   - b. ______ Base
   - c. ______ Paving - Asphalt/concrete
   - d. ______ Paving - Portland cement

8. ______ **Seeding**

9. ______ **Sodding**

10. ______ **Driveways and driveway aprons**

11. ______ **Guardrails, reflectors**

12. ______ **Painting**

13. ______ **Lighting**

14. ______ **Engineering**
    - a. ______ Engineering design
    - b. ______ Surveying stakeout

15. ______ ***Point out in cover letter items not included, such as:**
    - a. ______ Land costs
    - b. ______ Interest costs
    - c. ______ Inspection costs
    - d. ______ Builder's overhead
    - e. ______ Legal fees
    - f. ______ Onsite work
    - g. ______ Planning and preliminary engineering work
    - h. ______ Advertising and public relations
    - i. ______ Permits and bonds.

16. ______ **Riprap**

17. ______ **Gravel - various kinds**

18. ______ **Structural steel work**

19. ______ **Timber construction**

20. ______ **Temporary construction**
    - a. ______ Access roads
    - b. ______ Diversion ditches
    - c. ______ By-passes

21. ______ **Silt control**
    - a. ______ Seeding
    - b. ______ Silt basin

22. ______ **Contingency item (10%)**

FIGURE 29.1 Cost estimate checklist.

Project Name ______________________________

Prepared By ______________________________ Date ______________

Checked By ______________________________ Date ______________

Item	Quantity	Unit	Unit Price	Cost
A. Clearing and Grading				
1. Clearing and Grubbing		Acre		
2. Disposal		L.S.		
3. Excavation (cut)		C.Y.		
4. Embankment (fill)		C.Y.		
5. Borrow		C.Y.		
6. Spoil/Disposal		C.Y.		
7. Topsoil Removal/Storage		C.Y.		
8. ______________				
Sub-Total for Clearing and Grading				
B. Erosion/Sediment Control				
1. Earth Berm		L.F.		
2. Perimeter Dike		L.F.		
3. Interceptor Dike		L.F.		
4. Filter Fabric Fence		L.F.		
5. Gravel Filters: (Excl. filters with basins)		C.Y.		
6. Inlet Sediment Traps		Each		
7. Sod		S.Y.		
8. Seeding (disturbed area minus pavements and buildings)		S.Y.		
9. Sediment Basins (including filters)		Each		
10. Wash Rack (incl. water service)		Each		
11. ______________				
Sub-Total For Erosion/Sedimtent Control				
C. Streets				
1. Bituminous Concrete Surface: 1"		S.Y.		
2"		S.Y.		
2. Base Course: 6" Aggregate		S.Y		
3" Bit. Conc.		S.Y.		
3. Aggregate Sub-base		C.Y.		
4. Cement Treated Aggregate		C.Y.		
5. Cement Treated Sub-grade		C.Y.		
6. Surface Treatment		S.Y.		
7. Gravel Shoulder		S.Y.		
8. Curb & Gutter		L.F.		
9. Header Curb		L.F.		
10. Median Curb		L.F.		
11. Curb Cut Ramps		Each		
12. Commercial Entrance		L.F.		
13. Driveway Entrance		Each		
14. Guard Rail		L.F.		
15. Traffic Barricade		Each		

FIGURE 29.2 Cost estimate sheet.

16. Edge Delineators			Each		
17. Sidewalk (4' wide, concrete)			L.F.		
18. Rock Excavation			C.Y.		
20. Soil Testing (Road)			L.F.		
21.					
			Sub-Total for Streets		
D. Storm Sewer					
1. Easement Clearing & Restoration			L.F.		
2. Pipe RCCP, Classes II-IV:	15"		L.F.		
	18"		L.F.		
	21"		L.F.		
	24"		L.F.		
	27"		L.F.		
	30"		L.F.		
	33"		L.F.		
	36"		L.F.		
	42"		L.F.		
	48"		L.F.		
			L.F.		
3. Pipe, CMP:	15"		L.F.		
	18"		L.F.		
	21"		L.F.		
	24"		L.F.		
	27"		L.F.		
	30"		L.F.		
	33"		L.F.		
	36"		L.F.		
			L.F.		
4. Endwall	15"		Each		
	18"		Each		
	21"		Each		
	24"		Each		
	27"		Each		
	30"		Each		
	33"		Each		
	36"		Each		
			Each		
5. End Section	15"		Each		
	18"		Each		
	21"		Each		
	24"		Each		
	27"		Each		
	30"		Each		
	33"		Each		
	36"		Each		
	42"		Each		
	48"		Each		
			Each		
6. Endwall			Each		
			Each		

FIGURE 29.2 *(Continued)*

7. Curb Inlet		Each		
8. Other Inlets		Each		
		Each		
9. Junction Box JB-1 Pipe size: ____		Each		
____		Each		
10. Manhole		Each		
11. Modified Structure		Each		
12. Connect to Existing Structure		Each		
13. Remove Existing Structure		Each		
14. Pavement Restoration		S.Y.		
15. Curtain Wall		C.Y.		
16. Concrete Cradle/Encasement		L.F.		
17. Concrete Anchors		C.Y.		
18. Paved Ditch		C.Y.		
19. Sod Ditch		S.Y.		
20. Rip Rap: Class I Ungrouted		C.Y.		
Class I Grouted		C.Y.		
Class II		C.Y.		
21. Piling		L.S.		
22. Box Culvert (compute Cost on Box Culvert Computation Form)		L.S.		
23. Underdrains		L.F.		
24. ____________________		____		
		Sub-Total for Storm Sewer		

E. Sanitary Sewer

1. Easement Clearing & Restoration		L.F.		
2. Pipe,(Including 0-8' Trenching and Select Fill): 8"		L.F.		
10"		L.F.		
3. Pipe, RCCP (Including 0-8' Trenching and Select Fill): 8"		L.F.		
10"		L.F.		
4. Pipe, Ductile Iron (Including 0-8' Trenching and Select Fill): 8"		L.F.		
10"		L.F.		
5. Extra Trenching (Not includng Pipe): 8'-12'		L.F.		
12-16'		L.F.		
16'+		L.F.		
6. Manhole (All Manholes) 0'-8'		Each		
(Depth over 8') 8'+		V.F.		
7. Drop Connection		V.F.		
8. Concrete Encasement		L.F.		
9. Concrete Cradle		L.F.		
10. Concrete Anchors		C.Y.		
11. Rock Excavation		C.Y.		
12. Sheeting and Shoring		L.S.		
13. Pavement Replacement		L.F.		
14. Laterals: 4"		L.F.		
5"		L.F.		
15. Risers		V.F.		

FIGURE 29.2 *(Continued)*

16. "T" or "Y" Connection:				
8" x 4"	______	Each	______	______
8" x 5"	______	Each	______	______
10" x 4"	______	Each	______	______
17. Lateral Connection to Manhole	______	Each	______	______
18. Connect to Existing Structure	______	Each	______	______
19. Aerial Pipe Supports	______	L.S.	______	______
20. Boring or Jacking	______	L.F.	______	______
21. Select Fill Material	______	C.Y.	______	______
22. ______	______	____	______	______
		Sub-Total for Sanitary Sewer		______
F. Water Line				
1. Easement Clearing & Restoration	______	L.F.	______	______
2. Pipe, DIP: 3"	______	L.F.	______	______
4"	______	L.F.	______	______
6"	______	L.F.	______	______
8"	______	L.F.	______	______
10"	______	L.F.	______	______
	______	L.F.	______	______
3. Valve 3"	______	Each	______	______
4"	______	Each	______	______
6"	______	Each	______	______
8"	______	Each	______	______
10"	______	Each	______	______
	______	Each	______	______
4. Fittings (Tees, Bends Crosses, Reducers, and Offsets)	______	LB.	______	______
5. Copper Water Service (Includes Curb Stop) Note: Tap fee may cover this item	______	L.F.	______	______
6. Wet Tap	______	Each	______	______
7. Fire Hydrant	______	Each	______	______
8. Blow-off	______	Each	______	______
9. Air Release	______	Each	______	______
10. Rock Excavation	______	C.Y.	______	______
11. Boring and/or Jacking	______	L.F.	______	______
12. Pavement Restoration	______	L.F.	______	______
13. Shoulder Restoration	______	L.F.	______	______
14. Concrete Anchor/Encasement	______	C.Y.	______	______
15. Concrete Cradle	______	L.F.	______	______
16. Relocate Existing Hydrant	______	Each	______	______
17. Sheeting and Shoring	______	L.F.	______	______
18. Select Fill Material	______	C.Y.	______	______
19. ______	______	____	______	______
		Sub-Total for Water		______
G. Miscellany				
1. Septic Field	______	L.S.	______	______
2. Pump	______	Each	______	______
3. Monuments and Pipes	______	L.S.	______	______
4. Monuments and Pipes	______	Lot	______	______
5. Walkways and Trails: 4' Asphalt	______	L.F.	______	______
8' Asphalt	______	L.F.	______	______
4' Gravel	______	L.F.	______	______
4' Woodchip	______	L.F.	______	______

FIGURE 29.2 *(Continued)*

6. Landscaping	________	L.S.	________	________
7. Recreational Amenities	________	L.S.	________	________
8. Screening	________	L.S.	________	________
9. Fencing	________	L.S.	________	________
10. Retaining Wall	________	L.S.	________	________
11. Well	________	Each	________	________
12. Street Sign	________	Each	________	________
13. Wheel Stops	________	Each	________	________
14. ____________	________	________	________	________
		Sub-Total for Miscellaney		________

H. Total Cost		**Cost**
1. Sub-Totals:	Clearing and Grading	________
	Siltation/Erosion Control	________
	Streets	________
	Storm Sewer	________
	Sanitary Sewer	________
	Water	________
	Miscellany	________
	GRAND SUB-TOTAL	________
2. Engineering & Contingencies (%)		________
	TOTAL COST	________

Note: Cost Data Taken from available records.

FIGURE 29.2 *(Continued)*

ANALYSIS AND SOLUTION

You, as the engineer, are aware that the developer is seeking a 12 percent profit, or $15,000 per unit. You decide to evaluate the additional costs related to the incremental development (Phase II) against the required profit.

First, you determine the required incremental profit:

$15,000/unit × 12 units = $180,000 (required profit)

Based on a preliminary evaluation of elevations of the Phase II site, you estimate the cost of the fill required to be $75,000. You also perform an analysis for incremental infrastructure cost for Phase II and estimate the cost to be $60,000. You check with the local jurisdiction and find that the additional units in Phase II will increase traffic volumes on the primary access route, which also serves Phase I. The increase in traffic volume will require the road to have a wider cross section, and you estimate the incremental cost of the widening to be $20,000. The total incremental infrastructure cost for Phase II is $80,000.

Next, you estimate the additional cost for the deeper sewers in Phase I. You have been told by the developer's contractor that he would estimate the cost to be $2000 per unit for 25 percent of the Phase I units, or 15 units. This results in an additional cost for Phase I of $2000/unit × 15 units = $30,000.

You now compare the total incremental costs to the required profit:

Additional Cost for Fill (Phase II) = $75,000 (29.4)

Additional Cost for Infrastructure (Phase II) = $80,000

Additional Cost for Infrastructure (Phase I) = $30,000

Total Cost = $185,000

You now prepare a report to your client indicating that, based on your assumptions, he will not achieve the required profit, since the total incremental cost exceeds the required profit by $5000. You also advise that if any unforeseen costs were incurred that are not included in your evaluation it would make the differential even less appealing. You document your findings and assumptions clearly in the report to the client and include a copy of the report in the project files.

Specifics of Site

Development costs can vary greatly because of the specifics of the site. The provision of services, particularly utility ser-

TABLE 29.3 Procedure for the Preparation of Cost Estimates

All cost estimates shall be prepared by a *senior engineer* who shall, prior to beginning any quantity and cost estimate, undertake the following:

1. Secure the plan that is to be used as the basis for the estimate, and *clearly reference* a set of the plans as the source material upon which the estimate is predicated.
2. Research files and senior company engineers to determine what jobs, if any, have been done in the vicinity of the subject tract.
3. Obtain soil maps or reports of the tract under consideration, if available.
4. Conduct site inspection by physically walking the site, not just a "ride-by."
5. Use a standard cost estimate checklist and itemize each quantity or clearly state why the quantity is not defined.
6. Secure from a reliable source (reputable contractor, current bids, contractor's data report, recent cost estimates) unit costs for all improvements required.
7. Verify that costs secured are installed/finished construction prices.
8. Check all prices with another senior engineer to obtain concurrence on prices used.
9. Prepare chart-form cost estimate detailing type of improvement, quantity, units, unit cost, and total cost.
10. Have addition and multiplication cross-checked by another qualified person.
11. Prepare a cover letter to accompany all cost estimates, making the cost estimate an integral part of the letter (i.e., number of all pages—1 of 4, etc.). In this way the cost estimate should not get separated from the cover letter that qualifies the estimate.
12. The cover letter should enumerate that only those items listed in the cost estimate were considered. Additionally, it should detail those items that were not considered and why.
13. All cost estimates, regardless of how they are prepared, should qualify soil conditions and their possible effect on development costs.
14. All cost estimates must clearly define the source base plan used for the estimate.
15. All cost estimates must show the preparer of same and the date the estimate was prepared, irrespective of closing signature.
16. All cost estimates should be checked by senior staff prior to being sent to the client.
17. All cost estimates should clearly state that costs are based on present-day dollars.
18. All cost estimates should have rounded totals as final figures, which should include a 10 percent contingency factor added in at the end of the estimate.
19. All cost estimates should state the source of unit costs applied to the quantities.
20. Prepare the estimate in the order of construction events.
21. Include a base plan with the cost estimate and letter.

vices, can cause a wide disparity in costs between sites. If potable water, trunk sanitary, and/or storm sewer systems are not readily available, the provision of connections to these utilities can greatly increase construction costs for a project. The reconstruction or widening of a major highway can involve substantial construction costs attributable to the project and can have a serious impact on the per-unit costs.

If earthwork balance cannot be achieved, fill must be borrowed from an off-site source or excavation and embankment material must be exported. These earthwork transportation costs can seriously affect the economic viability of the site. Errors in estimating earthwork can lead to misleading profit percentages, and care must be taken to estimate these costs as accurately as possible. The quantity takeoff estimate has become much more accurate with development of a series of proprietary software packages, which allow for electronic compilation of quantities directly from the engineering design files, specifically for earthwork through comparison of digital terrain models (DTMs).

The political climate, particularly with respect to neighboring parcels, should not be underestimated. Costs to buffer or protect adjacent neighborhoods, using extensive landscaping, sound berms, or walls, can add to the project cost significantly. If possible, these costs should be estimated and included within early feasibility cost estimates.

SOURCES OF UNIT COST DATA

As important as quantities and contingencies are to cost estimating, the accuracy of the cost estimate also depends heavily on the accuracy of the unit cost data. When providing unit cost data for an estimate, it is recommended that the engineer check first with the client owner (or developer) to determine whether a relationship has been established with a reliable local contractor. If one exists, the contractor can provide information on recent bid data on similar projects, which is the best method of estimating unit costs. In some areas, local construction companies form trade associations to evaluate common problems and to promote their work. Frequently, these groups publish listings of recent successful bids. There are also nationally published bid tabulations such as the Bid Reporter and the Contractors Data Report. Many state departments of transportation publish recent bid tabulations from which general information on unit costs can be obtained.

Local public works agencies can also provide information on recent costs. Care must be exercised when using this information, since the construction costs for a public project may be different from those for privately constructed projects. An example of bid tabulation from a local agency is shown in Figure 29.3. In addition, many local governments require performance bonds for private projects. Many public agencies publish a unit price list to be used for the performance bond estimate. An example is shown in Figure 29.4. Care must be exercised by the engineer in using such information, as performance bond unit prices generally are higher than private construction costs, since additional amounts are included to reflect administration and start-up expenses when the agency must step in to complete a project.

In addition, there is published information generally identified as "Guides to Construction Costs." These include *Building Construction Data* by the RS Means Company, the Dodge Reports published by the F.W. Dodge Company, and *Engineering News-Record* published by McGraw-Hill. As a service to its readers, *Engineering News-Record* compiles and publishes an extensive amount of data on material prices and construction labor costs. A small amount of this data is then used to calculate two monthly index figures, the Construction Cost Index and the Building Cost Index. Each index is widely used throughout the U.S. construction industry as a benchmark for measuring inflation. These indexes can also be used to contemporize and correlate aged cost data with the base year of the estimate.

Other sources for cost guides include specialized trade associations such as the American Concrete Pipe Association and the Iron and Steel Institute, among numerous others. All of these guides are only that; the unit prices should never be used blindly, since conditions vary from region to region and, in fact, from project area to project area within the same jurisdiction.

ENGINEERING ECONOMY

Occasionally, the land development engineer is asked to assist the client in evaluating a series of alternatives (value engineering), which may involve a type of decision making called *engineering economic analysis*. The intent of presenting the following information is not to provide a complete discourse on the subject, but to summarize the formulas used in textbooks on the subject. The reader is directed to any of the engineering economy texts listed in the bibliography for a full explanation of the subject, as well as the necessary tables to apply the principles involved.

Interest Formulas

While texts on engineering economics use different symbols, the following are the ones most commonly used and are taken from a well-respected text on the subject (Grant, 1990).

Symbols

i = interest rate per interest period.
n = number of interest periods.
P = present sum of money.
F = sum of money at the end of n periods. It is equivalent to P with interest i added.
A = end of period payment or receipt in a uniform series continuing for n periods.

Formulas. The following information is provided to enable one to utilize the interest tables quickly when calculating the information needed to analyze engineering economy problems.

DESCRIPTION	QTY	MEAS.	Company A		Company B		Company C		Company D		Company E	
			UNIT PRICE	TOTAL	UNIT PRICE	TOTAL	UNIT PRICE	TOTAL	UNIT PRICE	TOTAL	UNIT PRICE	TOTAL
Clearing & Grubbing	1	LS	2,000.00	2,000.00	2,500.00	2,500.00	3,280.00	3,280.00	2,000.00	2,000.00	1,000.00	1,000.00
Construction Stakeout	1	LS	2,500.00	2,500.00	1,500.00	1,500.00	1,000.00	1,000.00	2,000.00	2,000.00	1,500.00	1,500.00
Maintenance of Traffic	1	LS	2,500.00	2,500.00	5,000.00	5,000.00	3,000.00	3,000.00	4,000.00	4,000.00	5,000.00	5,000.00
Temp. Concrete Barrier for M.O.T.	140	LF	10.00	1,400.00	15.00	2,100.00	12.00	1,680.00	20.00	2,800.00	40.00	5,600.00
Traffic Drums	50	EA	25.00	1,200.00	85.00	4,250.00	55.00	2,750.00	30.00	1,500.00	50.00	2,500.00
Temp. Pavement Tape Marking	1,020	LF	1.40	1,428.00	1.60	1,632.00	0.60	612.00	1.50	1,530.00	2.00	2,040.00
Class 1 & 2 Excavation	638	CY	15.00	9,570.00	18.00	11,484.00	20.00	12,760.00	22.00	14,036.00	39.00	24,882.00
Select Borrow	100	CY	15.00	1,500.00	5.00	500.00	5.00	500.00	22.00	2,200.00	10.00	1,000.00
Silt Fence for Sediment Control	600	LF	1.50	900.00	1.50	900.00	0.01	6.00	1.00	600.00	2.00	1,200.00
Test Pit Excavation Cont.	40	CY	50.00	2,000.00	10.00	400.00	35.00	1,400.00	50.00	2,000.00	5.00	200.00
Stabilized Construction Entrance	50	SY	25.00	1,250.00	11.00	550.00	11.00	550.00	15.00	750.00	10.00	500.00
Strawbales / Sandbags (Sed. Control)	50	EA	5.00	250.00	5.00	250.00	5.00	250.00	1.00	50.00	3.50	175.00
Temp. Curb Inlet Protection	3	EA	200.00	600.00	200.00	600.00	125.00	375.00	150.00	450.00	75.00	225.00
Select Borrow for Trench Bckfill	25	CY	40.00	1,000.00	5.00	125.00	22.00	550.00	24.00	600.00	10.00	250.00
15" RCP Class V	87	LF	35.00	3,045.00	83.00	7,221.00	60.00	5,220.00	35.00	3,045.00	60.00	5,220.00
18" RCP Class V	14	LF	50.00	700.00	87.00	1,218.00	55.00	770.00	60.00	840.00	60.00	840.00
Bituminous Concrete Base	162	TN	45.00	7,290.00	45.00	7,290.00	50.00	8,100.00	70.00	11,340.00	50.00	8,100.00
Bituminous Concrete Surface	126	TN	47.00	5,922.00	50.00	6,300.00	55.00	6,930.00	70.00	8,820.00	60.00	7,560.00
Aggregate Subbase for M.O.T.	50	TN	50.00	2,500.00	15.00	750.00	15.00	750.00	10.00	500.00	10.00	500.00
Calcium Chloride for M.O.T.	2	TN	250.00	500.00	300.00	600.00	350.00	700.00	50.00	100.00	200.00	400.00
Bitumin. Conc. (Cold Mix) M.O.T.	25	TN	50.00	1,250.00	45.00	1,125.00	50.00	1,250.00	50.00	1,250.00	30.00	750.00
Pavement Profiling (Milling)	552	SY/I	3.00	1,656.00	4.00	2,208.00	5.00	2,760.00	5.00	2,760.00	4.50	2,484.00
Poly. Paving Fabric for Bit. Conc.	120	SY	10.00	1,200.00	1.75	210.00	2.00	240.00	3.00	360.00	2.00	240.00
5" Conc. Sidewalk & S/W Ramps	185	SY	27.00	4,995.00	24.00	4,440.00	27.00	4,995.00	20.00	3,700.00	22.50	4,162.50
	TOTALS			57156		63153		60428		67231		76328.5

FIGURE 29.3 Bid tabulation example.

ARLINGTON COUNTY
DEPARTMENT OF PUBLIC WORKS
PUBLIC IMPROVEMENT PERFORMANCE BOND ESTIMATE

SUBDIVISION/SITE PLAN NAME ____________________

ADDRESS/LOCATION ____________________

SUBMITTED BY ____________________ DATE ____________________

Item	Quan.	Unit	Unit Price	Cost	Item	Quan.	Unit	Unit Price	Cost
Excavation including Clearing & Grubbing		Cu. Yds.	$23.75		Trees on Public R/W		Each	$330.00	
Conc. Curb & Gutter		Lin. Ft.	$15.00		Tree Grates		Each	$700.00	
Conc. Drive Entrance		Sq. Yd.	$35.00		Street Lights Type - Thoroughfare		Each	$6,000.00	
4" Conc. Sidewalk		Sq. Yd.	$25.50		Street Lights Type - Colonial		Each	$4,500.00	
Brick Paver Sidewalkon Aggregate Base		Sq. Yd.	$46.25		Restoration: Sod, etc.		Lump Sum		
Brick Paver Sidewalk on 4" Conc. Base		Sq. Yd.	$60.50		Erosion/Silt Controls		Lin. Ft.	$6.00	
Brick Paver Sidewalkon 6" Conc. Base		Sq. Yd.	$70.00		CB-2 Catch Basin		Each	$2,275.00	
Brick Paver Crosswalkon 6" Conc. Base		Sq. Yd.	$140.00		Catch Basin (misc.)		Each		
Wheel Chair Ramps		Each	$315.00		CB-2 Top Remove & Replace		Each	$1,225.00	
Bike Trail 4" Asphalt with 6" Comp. Subbase		Sq. Yd.	$17.00		MH-1 Storm Sewer Manhole		Each	$2,525.00	
Subbase - C.B.R. 30		Cu. Yd.	$29.00		MH-2 Storm Sewer Manhole		Each	$3,300.00	
B-3 Bituminous Concrete Base		Ton	$57.00		Storm Sewer Manhole (misc)		Each		
S-5 Bituminous Concrete Top		Ton	$60.00		MH-1 Top Remove and Replace		Each	$1,000.00	
Remove Conc. Curb & Gutter		Lin. Ft.	$7.00		MH-2 Top Remove & Replace		Each	$1,250.00	
Remove Conc. Sidewalk		Sq. Yd.	$5.00		15" R.P.C. Cl. III Pipe		Lin. Ft.	$44.00	
Remove Conc. Drive Entrance		Sq. Yd.	$6.00		18" R.P.C. Cl. III Pipe		Lin. Ft.	$48.00	
Conc. Retaining Wall		Cu. Ft.	$19.50		24" R.P.C. Cl. III Pipe		Lin. Ft.	$63.00	
Stone Retaining Wall		Cu. Ft.	$12.50		____ R.P.C. Cl. III Pipe		Lin. Ft.		
Storm Water Detention System		Lump Sum							

FIGURE 29.4 Bid tabulation example.

Item	Quan.	Unit	Unit Price	Cost	Item	Quan.	Unit	Unit Price	Cost
4" Water Line D.I.P. Class 52		Lin Ft.	$45.00		8" San Sewer Pipe Less than 10' Deep		Lin Ft.	$55.00	
6" Water Line D.I.P. Class 52		Lin. Ft.	$51.00		8" San Sewer Pipe Greater than 10' Deep		Lin Ft.	$160.00	
8" Water Line D.I.P. Class 52		Lin. Ft.	$55.00		15" San. Sewer Pipe Less than 10' Deep		Lin. Ft.	$80.00	
12" Water Line D.I.P. Class 52		Lin. Ft.	$64.00		15" San. Sewer Greater than 10' Deep		Lin. Ft.	$210.00	
16" Water Line D.I.P. Class 52		Lin. Ft.	$78.00		4' I.D. San. Sewer M.H.		Vert. Ft.	$300.00	
6x6 Tapping Sleeve and Valve		Each	$2,200.00		5' I.D. San. Sewer M.H.		Each	$350.00	
8x8 Tapping Sleeve and Valve		Each	$3,150.00		San M.H. Adj. to Grade		Each	$350.00	
12x12 Tapping Sleeve and Valve		Each	$4,150.00		Tunneling 24" Carrier Pipe		Lin. Ft.	$750.00	
16x12 Tapping Sleeve and Valve		Each	$4,068.00		Traffic Signalization*		Lump Sum		
24x12 Tapping Sleeve and Valve		Each	$8,050.00						
2' Blow Off Valve		Each	$1,500.00						
Fire Hydrant		Each	$1,325.00						
Fire Hydrant (relocate)		Each	$1,000.00						

*Contact the Department of Public Works Traffic Signal Engineer on 358-3575 for cost if required by this subdivision/site plan.

ADDITIONAL ITEMS

SUB-TOTAL ________

20% ADMINISTRATIVE, ENGINEERING & MISC. FEE ________

TOTAL QUOTE ________

REVIEWED AMOUNT APPROVED BY ARLINGTON COUNTY (FOR COUNTY USE ONLY ________

BY________________ DATE________________

FIGURE 29.4 *(Continued)*

$$F = P(1 + i)^n \quad (29.5)$$

$$P = F\left[\frac{1}{(1 + i)^n}\right] \quad (29.6)$$

$$A = F\left[\frac{i}{(1 + i)^n - 1}\right] \quad (29.7)$$

$$A = P\left[\frac{i(1 + i)^n}{(1 + i)^n - 1}\right] \quad (29.8)$$

$$F = A\left[\frac{(1 + i)^n - 1}{i}\right] \quad (29.9)$$

$$P = A\left[\frac{(1 + i)^n - 1}{i(1 + i)^n}\right] \quad (29.10)$$

The factors, which vary by interest rate and number of periods, are found in most engineering economic analysis texts. They are usually written as (Factor, I, n). For example, the uniform series present-worth factor at $i = 7$ and for $n = 10$ would be written as (PWF, i, n) or (PWF, 7%, 10), and is equal to 0.5083. This factor can be determined by looking at a table or by substituting the values into Equation 29.5. When solving complex engineering economics problems, it is a good idea to draw a cash flow diagram. A simple problem illustrates.

EXAMPLE 3

How much does one have to invest today to be able to achieve draws of $2000 at the end of each year for five years, assuming interest is at 7 percent per year?

First, prepare a cash flow diagram (Figure 29.5). To find P given A at $n = 5$ and $i = 7$,

$$P = A\,(\text{Present Worth Factor}) \quad (29.11)$$

$$= A\,(\text{PWF}, 7, 5)$$

$$= 2000\,(4.100)$$

$$P = \$8200$$

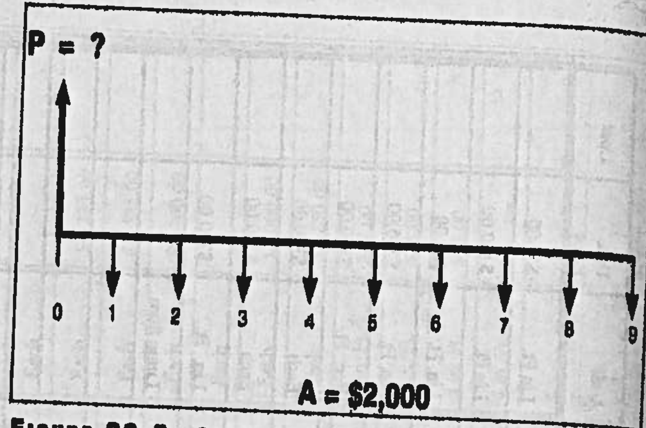

FIGURE 29.5 Cash flow diagram for example 3.

The next problem is included as an example of alternative analyses that are commonly encountered in land development engineering. It uses the principles of engineering economics as described previously.

EXAMPLE 4

You are the engineer for a major landowner and developer. Your client needs to construct a storm drainage facility that extends under a state roadway. Your client has requested that you compare two alternative storm drainage pipe systems and has provided you with two bids from his contractor. Alternative A has a service life of 50 years and a bid cost of $1,575,800. Alternative B has a service life of 25 years with a construction bid of $1,275,000. Since your client will be the owner over the life of the facility, he wants to be sure he selects the least-cost alternative over the long term.

You, as the engineer, investigate and find that the state highway department requires a service life of 50 years, meaning that Alternative B could require replacement once during the service life of the project. You are aware that inflation is at 4 percent and interest rates are at 7 percent.

ASSUMPTIONS/FACTS	ALTERNATIVE A	ALTERNATIVE B
Bid cost (P)	$1,575,800	$1,275,000
Life (n)	50 years	25 years
Interest (I)	7%	7%
Inflation	4%	4%

Your client has asked you to compare the life cost for each alternative on an annual cost basis.

For alternative A, using the economic analysis equation for annual equivalent cost (see Engineering Economics Tables):

$$A = P\left[\frac{i(1 + i)^n}{(1 + i)^n - 1}\right] = P\,(\text{CRF}, 7\%, 50\text{ yrs}) \quad (29.12)$$

$$= 1{,}575{,}800\,(0.07246)$$

$$A = \text{Annual Cost}_{\text{ALT A}} = \$114{,}182$$

In Alternative B, the pipe is assumed to need replacement in 25 years, since the service life is 25 years. Here you assume that, at an inflation rate of 4 percent per year, the cost to replace in 25 years is:

$$S_{25} = P(1 + i)^n = P(\text{CAF}, 4\%, 25\text{ yrs}) \quad (29.13)$$

$$= 1{,}275{,}000\,(2.6658)$$

$$S_{25} = \$3{,}398{,}895$$

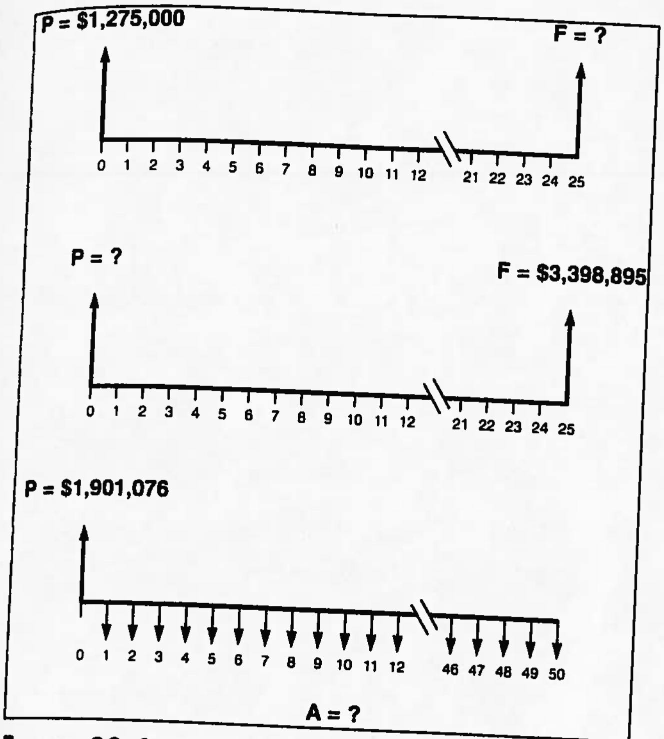

FIGURE 29.6 Cash flow diagram for Example 4.

Next, find the present value of $3,398,895 using i = 4%.

$$P = S\left[\frac{1}{(1+i)^n}\right] = S\,(\text{PWF, 7\%, 25 yrs})$$
$$= 3{,}398{,}895\ (0.1842) \qquad (29.14)$$
$$= \$626{,}076$$

Adding this value to the first installation cost, you find $1,275,000 + $626,076 = $1,901,076 for the total present value of Alternative B. Since you have been asked to compare the alternatives on an annual cost basis, you calculate:

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$
$$= P\,(\text{CRF, 7, 50 yrs}) \qquad (29.15)$$
$$= 1{,}901{,}076\ (0.07246)$$
$$A_{ALT\,B} = \$137{,}752$$

Figure 29.6 is a diagram that shows Alternative B cash flows for each step.

Note that the whole computation process of finding the annual cost could have been done in one step:

$$A = (P\,(\text{CAF, 4\%, 25})(\text{PWF, 7\%, 25}) \times (\text{CRF, 7\%, 50}) + P)\,(\text{CRF, 7\%, 50}) \qquad (29.16)$$

Based on the preceding assumptions on an annual equivalent cost basis, Alternative A is $114,182 per year and Alternative B is $137,752 per year. In this example, no cost of removing the pipe at 25 years is included. You advise your client that Alternative A, with the higher current bid cost, is the least-cost solution over the life of the facility (50 years). You prepare a report to your client documenting your analysis and assumptions and put a copy in the project files.

SUMMARY

Accurate, all-inclusive, and timely cost estimates are indispensable mechanisms in all stages of a development project, large or small. All assumptions and quotes from suppliers/vendors/manufacturers/specialty contractors must be presented in clear and dated notes. The size of the project determines the potential complexity and multistage levels of cost estimating required.

While quantity takeoff for the project requires a thorough understanding of the engineering drawings and specifications, it also requires significant engineering judgment, diligence, and research to procure accurate, current-unit-cost data that is reflective of the size, type, location, and timing of the project as well as the current state of the economy and financial facets of the project.

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