Appendix H

Development of Construction Costs

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APPENDIX H

Development of Construction Costs

Pre-appraisal, reconnaissance-level field (direct) construction cost estimates were prepared for potential new storage opportunities for consideration during future planning, investigations, and site comparisons. Rough field construction cost estimates of project features are commonly developed during pre-appraisal, reconnaissance-level assessment for the purpose of comparing alternative sites and determining/comparing the size and scope of development.

Civil engineering works of this type (reservoirs, dikes, diversions, dams, pipelines, etc.) are very site-specific. Initial cost evaluations are generally completed in a series of steps from map studies during appraisal/feasibility-level analysis, to more detailed site visits (including surveying and geologic evaluation) that support conceptual design development, and preliminary and final design. Thus, project development is an iterative process, where cost estimates are revised as more details of the site are developed. As project details are developed, the accuracy and dependability of the cost estimates increase.

In addition to the cost of the dam/reservoir itself, other costs associated with access roads, relocations, property, design costs, etc. also need to be considered. At this pre-appraisal, reconnaissance-level of project development, cost estimates are useful for a very rough comparison, screening, and evaluation of projects. Future phases of analysis (appraisal-/feasibility-level) generally include survey, geologic investigation, drilling, sampling, and testing of foundation and borrow materials to assess the feasibility of any project. Despite these best engineering efforts, additional surprises can still occur during construction (that may result in change orders). Thus, the design of a dam/reservoir is not completed until the construction is completed and the reservoir and dam are functioning satisfactorily.

H.1 Non-Field Costs

Field costs are not the total cost necessary to complete a project, and do not include costs such as engineering, contract administration, land acquisition, permitting, environmental documentation, or mitigation. Total costs for project implementation would be substantially larger than the estimated field construction costs. Because new reservoir siting and development projects are not common in today’s political environment, non-field costs related to permitting, environmental documentation, or mitigation are unknown at this time. Reclamation records and industry standards suggest that non-field costs might constitute up to 25 percent of field costs. Thus, total costs for project implementation would be substantially larger than the estimated field construction costs.

H.2 Field Costs

All field costs are indexed up to 2010 dollars and include allowances for mobilization, unlisted items, and contingencies as a percentage of the subtotal field construction cost, as follows:

- Mobilization at 5 percent
- Unlisted items at 10 percent
- Contingencies at 25 percent

Field costs were prepared using unit costs for the major facilities that would comprise the overall project—specifically, pump stations, pipelines, and the reservoirs themselves. The following sections describe the approach, assumptions, and unit costs used to prepare the estimates for these major components.

H.2.1 Pump Stations

Pump station costs were extended from a unit price of $2,000 per horsepower, representing a typical pre-appraisal-level cost for a facility consisting of a simple building, a spare pump, and other standard components, but no emergency generators or custom architectural treatments. Assumptions and approach for estimating horsepower were as follows:

- Static pumping head was estimated based on the elevation difference between the water source (typically the Boise or Payette River or one of their respective forks) at a location in immediate proximity to the offsite reservoir, versus the elevation of the apparent high point along the pipeline route.
- It was assumed that siphoning over the high points would not be feasible because of the magnitude of the vacuum that would be developed in most cases.
- Tunneling was not considered at this stage as a means of reducing static lift.
- Friction losses through the pipeline contributing to total dynamic pumping head were estimated using the Hazen Williams equation with a C factor of 130, which is typical for the types of pipe expected and some degree of aging of the pipe material.
- Costs were based on a single pump station, rather than multiple pump stations in series. The latter configuration may ultimately prove more feasible and alter costs to some degree.
- Design flows were estimated as described in Section 4.2.4.

H.2.2 Pipelines

Pipeline costs were extended from a unit price of $10 per-inch-diameter per-foot length, representing a typical open-trench installation of large-diameter pipe and appurtenances. Pipe would likely be welded steel with provisions for corrosion and/or cathodic protection. Assumptions and approach for estimating horsepower were as follows:

- Pipeline lengths were estimated by simple scaling of a straight line from the water source to the reservoir site, plus an approximate 25 percent allowance to cover deviations in the alignment.
- Costs were based on a single large pipeline, rather than multiple smaller pipelines in a common trench.
- Tunneling was not considered at this stage as an alternative to open trenching, but could ultimately prove to provide some economies in certain areas.
- Design flows were estimated as described in Section 4.2.4.
- Pipe diameter was sized based on an average flow velocity of 7 cuffs, commonly used as a rule of thumb in balancing pipe costs with friction losses and pumping costs.

- The topography and geology along the pipe line route have a great effect on the construction cost of a pipeline. Access to the alignment, stability of the route, trench excavation, environmental sensitive areas, stream crossing, etc. will affect the cost of the project. Thus, until site-specific information becomes available, these costs provide only a rough comparative cost.

H.2.3 Reservoirs

Construction costs for the reservoirs primarily represent the cost of the dam or dikes plus the hydraulic structures. At the pre-appraisal, reconnaissance-level stage of project evaluation, many assumptions were made because specific information (primarily detailed topography and geology) is not available. To compare sites, a very general cost per acre foot was applied during this initial cost screening of potential reservoir sites, which reflects the assumption that all sites are generally similar, with the volume of storage being the major discriminator.

Construction costs for several reservoir projects with a wide range of reservoir capacities were extended from unit costs based on volume of storage. A collection of construction costs for a broad variety of projects constructed over the past several decades by various agencies was used to develop a cost table that was indexed up to the present using annual price indexes, and indexed up to 2010 dollars using 5 percent inflation per year.

During future phases of analysis, more detailed information can be developed and these costs can be refined in an iterative process. This information includes topography and geology (which determine the foundation and type of dam/dike), as well as foundation and reservoir bottom treatment (including cutoff trenches, grout curtains, and dewatering).

As more information is developed, various dam types, including earth fill, rock fill, concrete, and roller-compacted concrete can be evaluated for compatibility with the site. Also, availability of suitable construction materials for the dam components can be evaluated , such as core, filters, drain, shell, and random for embankment dams/dikes or concrete aggregate for concrete or RCC dams.

The hydraulic structures (intakes, outlets works, spillway, and diversion works, etc.) can also represent a large part of construction costs and can be evaluated in conjunction with the reservoir.

H.2.4 Design Flows, Exceptions, and Other General Elements of Facility Sizing and Costing

Design flows for pipelines and pump stations were estimated using available flow records or modeling results for the applicable reaches of the source streams. Conveyance and pumping structures were sized for costing purposes to accommodate peak flows that would be expected only 10 percent of the time and represent relatively high volumes. Peak flow rates were selected wherever possible such that a given reservoir would be filled in the 2- to 4-month late spring/early summer runoff period at a rate that would not completely deplete downstream flows in the system. This approach assumed a more concentrated and abbreviated diversions period to storage. This provides a more conservative cost basis in the event that water rights, instream flow requirements, or environmental restrictions dictate shorter diversion periods and larger facilities.

In the larger reservoir and smaller watershed situations, where estimated flows would not fill the reservoir 10 percent of the time, the approach was to select a peak design flow similar to that of the highest estimated monthly flows. In this case, it is assumed that the reservoir could only be filled in wetter years, and capacity would be available in those instances.

The following list summarizes other key assumptions and exceptions to the cost estimating approach:

- Does not include any costs to distribute stored water from the new reservoirs to downstream uses.
- Does not include diversion facilities at the water source (e.g., weirs or dams across the stream to control or enhance diversions).
- Does not include any hydropower facilities as a means of offsetting annual pumping costs.
- For cases in which the diverted water from the source is discharged well upstream of the new reservoir, it is assumed that the channel has adequate capacity to convey the peak flows down to the reservoir, and no costs for enlargement or channel modifications are included.

H.3 Summary of Field Costs

Field cost estimates are summarized in Table H-1. These costs only cover potential new facilities; cost estimates associated with retrofitting existing facilities are summarized and referenced in the Literature Report (Appendix D).

Table H-1. Summary of Field Cost Estimates by New "Area of Opportunity"

Area of Opportunity	Reservoir Capacity Range (AF)	Cost Range (Millions)
1 – South Fork Boise	100,000	$410-600
2 – North Fork/Middle Fork Boise	100,000	$150-380
3 – Lower South Fork Payette	50,000-300,000	$170-1,290*
4 – Lower North Fork Payette	50,000-300,000	$170-1,200*
5 – Mainstem Payette	50,000-300,000	$190-1,200*
6 – Lower Payette	50,000-300,000	$140-450

*Costs for larger reservoir projects in these "areas of opportunity" are greatly influenced by the cost of pumping facilities necessary for inter-basin and/or trans-basin transfer.

These ranges reflect the limited site-specific information available during the pre-appraisal/reconnaissance-level assessment. The lower-end costs are associated with on-stream facilities that do not require pump stations or pipelines, or off-stream facilities that are located relatively near to their source water. Many of the higher-end costs associated with inter-basin and/or trans-basin transfers are related to high pump station costs associated with the larger reservoir sizes. If larger reservoirs are sited in areas that do not require pumping in between basins, the higher-end costs could decrease.