Cost Estimate for a 3000-meter Clean Hot Water Drill

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Executive Summary

This document presents a material-only cost estimate for a 3000-meter clean hot water drill with an anticipated total value of $2.75 million. The estimate integrates vendor-quoted pricing, past purchase data, and engineering estimates, providing a defensible basis for planning, budgeting, and funding decisions.

The estimate includes major subsystems such as power generation, water storage, pumping systems, heating, filtration and UV treatment, drilling hose and winch systems, monitoring and controls, and structural components.

Project Overview

The objective of this paper is to provide a comprehensive cost estimate for a deep hot-water drilling system suitable for clean access to subglacial environments. The scope of the cost estimate encompasses the material costs required to build and field the system, including spares. The estimate does not include labor costs for the design, assembly, testing, or operation of the drill.

The design of the system is heavily based on the British Antarctic Survey's (BAS) clean hot water drill system, which is described in detail here[i]. Slight adjustments were made to the sizing of components to enable the system to reach an increased depth of 3000m.

Methodology for Cost Estimation

The basis of each estimate was categorized into one of three categories:

1. **Quoted** – Direct vendor quote or current online pricing

2. **Past Purchase** – Costs derived from past procurement of an equivalent component, adjusted for inflation

3. **Estimated** – Engineering judgement used for a conservative estimate

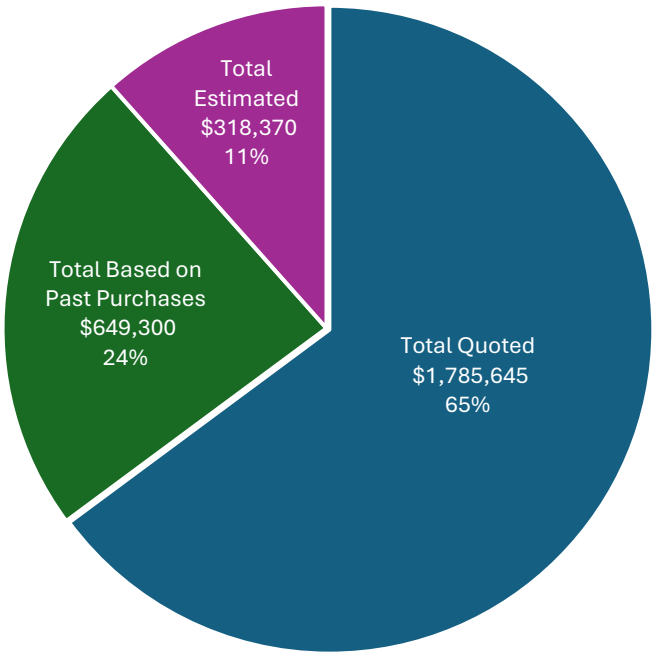


Figure 1: Distribution of the cost estimate by basis of estimate.

Summary of Major Cost Categories

Generators & Power Distribution

Includes main generators, power distribution boxes, and small auxiliary generators. Required to provide electric power to the pumps, winch, heaters, and controls.

Water Tanks

Includes large water tanks for clean and dirty water storage, heaters for melting seed water, and small tanks for initial system priming.

Low-Pressure Pumps

Includes stainless steel pumps, fittings, and hoses for circulating water through the main heating plant and filtration system.

Main Heating Plant

Includes fuel-fired water heaters, fittings, and hoses. Provides the heating capacity to raise the water flow's temperature above 90°C.

Heat Exchangers

Includes stainless steel plate heat exchangers, fittings, and hoses. Required to transfer heat from the "dirty" water loop to the "clean" water loop.

Filtration & UV Sterilization

Includes multi-stage submicron filtration, disinfection UV units, Total Organic Compound (TOC) reduction UV units, differential pressure gauges, fittings, and hoses. Required to filter and disinfect the drill water to levels appropriate for subglacial access.

High-Pressure Pumps

Includes stainless steel triplex pumps, motors, drives, pulsation dampeners, pressure relief valves, fittings, and hoses. Required to provide the high-pressure water flow needed to deliver drill water to the borehole.

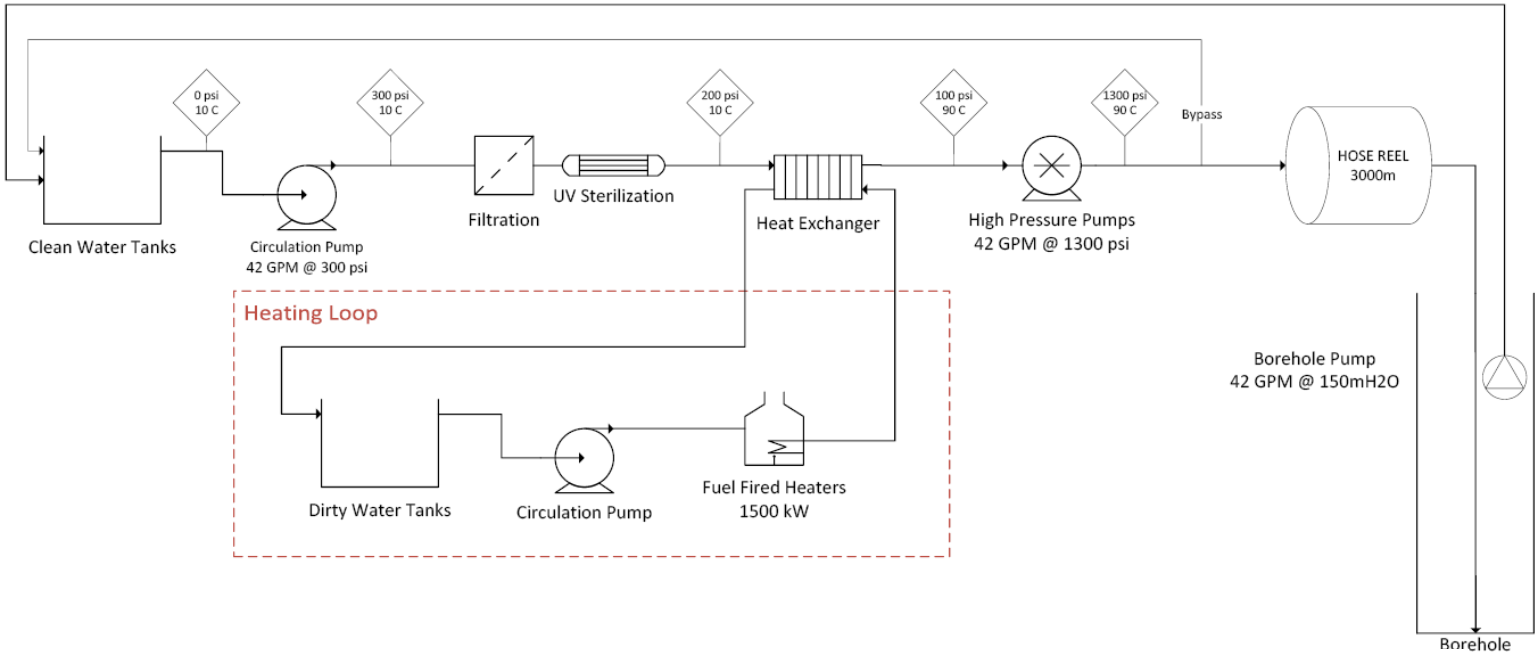


Figure 2: Simplified process flow diagram of the hot water drill system. Values to be used for equipment sizing reference only, not for subsequent design phases. A more detailed schematic of such a system is shown in Figure 4 of Makinson et. al., 2021[1].

Winch, Tower, Hose, & Nozzle

Includes 3100 m of 1 ¼" ID drill hose, hose winch, tower, and downhole nozzle assembly.

External Hose Cleaning

Includes high pressure washdown box, annular air knife with HEPA filtered blower, UV-C sterilization system required to clean the outside of the drill hose to levels appropriate for subglacial access.

Borehole Umbilical

Includes borehole pumps, drives, spray block manifolds, water level sensors, hoses, cables, fittings, and crescent sheaves. Required to pump water out of the borehole for recirculation.

Monitoring & Controls

Includes sensors for pressure, temperature, flow, and level monitoring. Includes encoders and load cells for drill progress monitoring. Includes digital display and signal conversion components. Includes servers, ethernet components, and laptops.

Includes control box components: enclosure, central controller, relays, power supplies, terminal blocks, connectors, buttons, switches, and indicators.

Includes components for a clip-on borehole measurement system with sensors measuring hole diameter, 9-axis telemetry, pressure, and temperature. Data would be available for download when the hose is on the surface.

Interconnects

Includes water hose, fuel hose, power cables, and signal cables for connecting between modules. Includes water manifolds, valves, and gauges for monitoring pressure, temperature, and flow.

Structures & Miscellaneous

Includes a tent for the main heating plant, a tent for borehole operations, a soft-wall clean room, pallet sleds for each module, a set of tools, and a set of shipping cases.

Cost Summary Table

Table 1: Breakdown of the cost estimate by category.

Cost Category	***Total Cost***	
Generators & Power Distribution	$	307,200
Tanks	$	35,578
Low-Pressure Pumps	$	51,469
Main Heating Plant	$	137,000
Heat Exchangers	$	74,000
Filtration & UV Sterilization	$	102,070
High-Pressure Pumps	$	388,224

Winch, Tower, Hose, & Nozzle	$	717,826
External Hose Cleaning	$	321,935
Borehole Umbilical	$	241,313
Monitoring & Controls	$	119,685
Interconnects	$	95,585
Structures & Miscellaneous	$	161,431
Final Estimate	*$*	*2,753,315*

Credibility of Cost Estimate

IDP believes that this is a strong, defensible cost estimate due to:

1. The basis of estimate for 89% of the dollar amount is either direct vendor quotes, online pricing, or inflation-adjusted from past purchases of equivalent equipment.

2. The total cost is within 20% of the value provided by BAS for the cost of their clean, deep hot water drill system.

Field Logistics and Fuel Use

This system will require a tractor traverse to be transported to its field site, as not all the components will fit into a Twin Otter or Basler aircraft. Specifically, the winch and 3000 meters of hose are too large to be transported by small aircraft.

Estimated fuel use for a single hole to 3000-meters depth is 3700 gallons, or close to 70 drums. This estimate is extrapolated from BAS field data where three 30-cm diameter holes were hot water drilled to 2150 meters. Additional fuel should be on hand for any planned reaming activities and for contingency.

Acknowledgments

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[i] Keith Makinson , Paul GD Anker, Jonathan Garcés, David J Goodger, Scott Polfrey, Julius Rix, Alejandro Silva, Andrew M Smith, José A Uribe, Rodrigo Zamora (2021) Development of a clean hot water drill to access Subglacial Lake CECs, West Antarctica. *Annals of Glaciology* , 62 , 85-86 , 250-262 . doi: 10.1017/aog.2020.88