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Reservoir Modeling from Exploration to Expansion: The Ormat Reservoir Modeling Workflow

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ABSTRACT

Numerical reservoir modeling is a critical tool for analyzing and optimizing geothermal development, requiring thoughtful deployment to be effective. As of January 2026, Ormat has an operational portfolio of 30 geothermal fields and is actively exploring for future developments. Supporting these efforts with modeling demands efficient workflows, high-caliber conceptual models, phase-specific modeling scopes, and external expert review.

Ormat's project phases (exploration, long-term testing, development, and operations) each require distinct modeling approaches. During exploration, modeling begins after a full-size production well is drilled and becomes more rigorous as testing progresses. The model is finalized after long-term testing to guide a sustainable and economic development.

Within the first two years of commercial operations a major model update incorporates the refined conceptual model, production/injection behavior, and tracer test results. This updated model supports Ormat's staged development strategy by guiding expansion and optimization strategies for long-term operations.

During ongoing operations, efficient workflows enable quarterly model updates which integrate operating data and may identify the need for more comprehensive revisions. These larger updates are conducted as needed to pursue generation increases or mitigate reservoir decline.

Throughout the modeling lifecycle, Ormat engages external reviewers to validate model assumptions, ensure alignment with industry best practices, and confirm appropriate calibration. This external review process enhances confidence in the model's reliability and its validity as a decision-making tool across all project phases.

1 INTRODUCTION AND PURPOSE OF NUMERICAL RESERVOIR MODELING

This paper describes the usage of numerical reservoir modeling ("reservoir modeling") at Ormat Technologies ("Ormat"). As of January 2026, Ormat has an operational portfolio of 30 geothermal fields, with 1090 MW of geothermal capacity, and is actively exploring globally. This high number of distinct fields and ongoing exploration efforts motivate a reservoir modeling workflow that has proven successful at supporting our global operations and growth.

In the context of this paper, "reservoir modeling" refers to numerical reservoir simulation, specifically finite-difference simulation of full geothermal fields. Other models are used, such as wellbore models (modeling flow within a wellbore for production or injection wells), pressure transient models (analytical or numerical models intended to replicate pressure build-up or fall-off), and process models (simulations of subsets of reservoirs or simplified models to test physics). These important tools will only be addressed briefly in this paper.

At Ormat, the primary purpose of reservoir modeling in geothermal development is to predict the future behavior of a geothermal reservoir. Specifically, the reservoir model is used to predict flow, enthalpy, pressure, power generation, and in some cases fluid composition distribution/change over time. By predicting future behavior, a reservoir model supports optimum development and operations of geothermal fields. At Ormat, models are "fit for purpose"; we do not set a standard of perfect accuracy in calibration or forecasting, but if a model is not suitably predictive, it is updated or not used (see Figure 1, a replication from Ma (2010)).

The secondary purpose of reservoir modeling at Ormat is to serve as a repository of reservoir engineering and geoscience data, wherein the calibration process is a mechanism of integrating and honoring these interrelated datasets while introducing the real physics of fluid flow and thermodynamics.

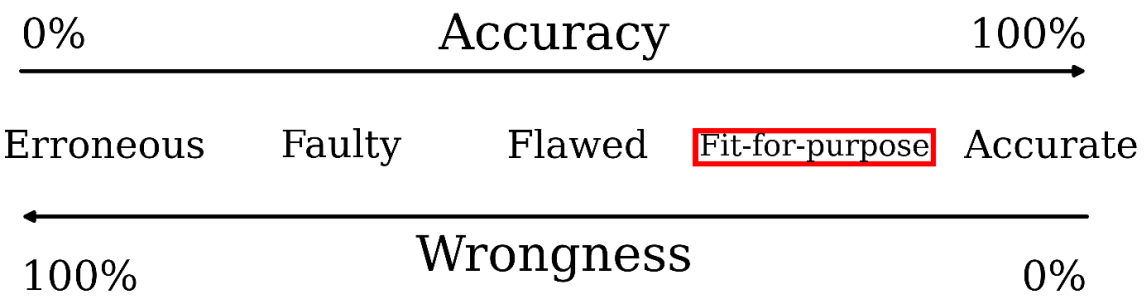


Figure 1: Accuracy Spectrum, Reproduced from Ma (2010), with Highlight Added

2 THE GEOTHERMAL RESERVOIR AS A SYSTEM

To appropriately utilize reservoir modeling, it is useful to consider the system that a reservoir model is intended to represent. An operating geothermal field is a hierarchical system comprised of many subsystems (Meadows, 2008 pp 83), chiefly:

- Natural fluid flows into and out of the reservoir (dominantly an inflow of high enthalpy water)
- The heat stored in rock resulting from conductive and convective heat accumulation
- Rock and fractures, some of which host permeability
- The changes to these rocks resulting from water/rock/heat interaction (e.g. alteration or mineralization)
- The changes to mobile fluids as result of water/rock interaction
- The hydraulic properties of the rocks and fractures
- The boreholes (wells) which connect the subsurface rocks and surface facilities
- The surface engineering systems which convert heat energy into electricity
- Others as applicable

Each of the subsystems listed above can be analyzed independently within the technical disciplines of geothermal development and operations, including geology, geophysics, geochemistry, drilling engineering, production engineering, power plant engineering and operations, and reservoir engineering (reservoir modeling being a sub-discipline of reservoir engineering). A model could hypothetically capture all the subsystems listed above but a practical approach requires identifying which systems should be modeled and in what level of detail. Through the modeling and development of many geothermal fields, Ormat has identified the following elements which are most important to include in a reservoir model. This approach leverages reservoir modeling as the best tool to represent these aspects of reservoir performance:

- Natural inflows/outflows
- Heat accumulation and heat-transfer
- The hydraulic properties which govern fluid flow in porous media
- Impact of reservoir pressure and enthalpy on well performance

Ormat uses the Volsung simulator suite for reservoir modeling and wellbore simulation (Franz and Clearwater, 2020). The other key subsystems which contribute to the reservoir model but are not modeled explicitly are incorporated in these ways:

- Rocks, fractures, and elements of alteration/mineralization are represented in a 3D geologic conceptual model which is upscaled and serves as an input to the reservoir model. Ormat uses Seequent's Leapfrog geologic modeling software which allows for export of geologic conceptual model features with 3D fidelity into Volsung reservoir models.

- Fluid properties are modeled in-depth by geochemists but are greatly simplified for reservoir modeling, either to pure water or to an equation of state using CO_2, NaCl, and water. High concentrations of other soluble components may be tracked as separate water components depending on the model need, such as modeling reservoir tracers, tracking marginal fluid incursion or chloride concentration changes.
- Surface engineering systems are also greatly simplified for reservoir models, using simple conversion equations (linear or quadratic, sometimes piecewise) to calculate power generation from flow, pressure, and enthalpy. These calculations are enabled through Volsung's capability of integrating surface models with subsurface reservoir models.
- Boreholes are represented explicitly if coupling wellbore models to the reservoir model but are generally neglected in pumped systems, except for the location in space of feedzones which intersect the reservoir.

Depending on the context, reservoir modelers may prioritize rigorous modeling of additional subsystems (including geomechanics or water-rock interaction). In the context of currently available modeling software and the specific goals of modeling conventional geothermal systems, Ormat has not prioritized these physics, specifically because adding them would significantly increase both the set-up time and model computation time while having a very limited benefit to calibration and forecasting accuracy. Figure 2 depicts the generalized relationship of geoscience and well data to the conceptual model and the translation of specific conceptual model features to a calibrated reservoir model.

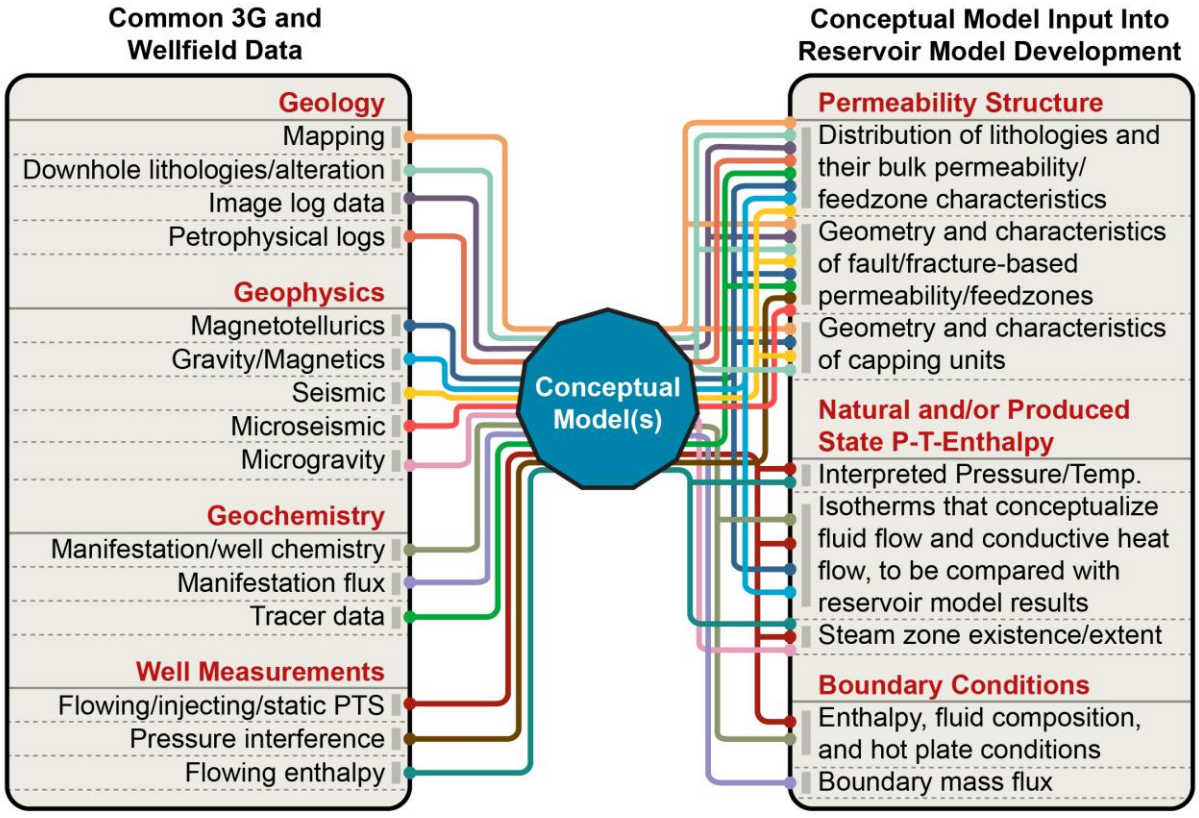


Figure 2: Data Mapping from Conceptual Model Source to Reservoir Model

3 MODELING AND THE ORMAT DEVELOPMENT PROCESS

Figure 3 shows the phases of geothermal field development at Ormat, a process beginning with geoscience, small-diameter drilling, and followed by full-size drilling and long-term testing (Webbison et al., 2026). The understanding of reservoir capacity is refined throughout this process. Before full-size drilling, analogs provide the most useful prediction of reservoir capacity, and reservoir models are not used. With full-size drilling and long-term testing (Phases 4 and 5), sufficient data is collected to calibrate a useful reservoir model, and after

Phase 5 concludes, the reservoir model is the primary measure or reservoir capacity (although analogs continue to hold significant weight).

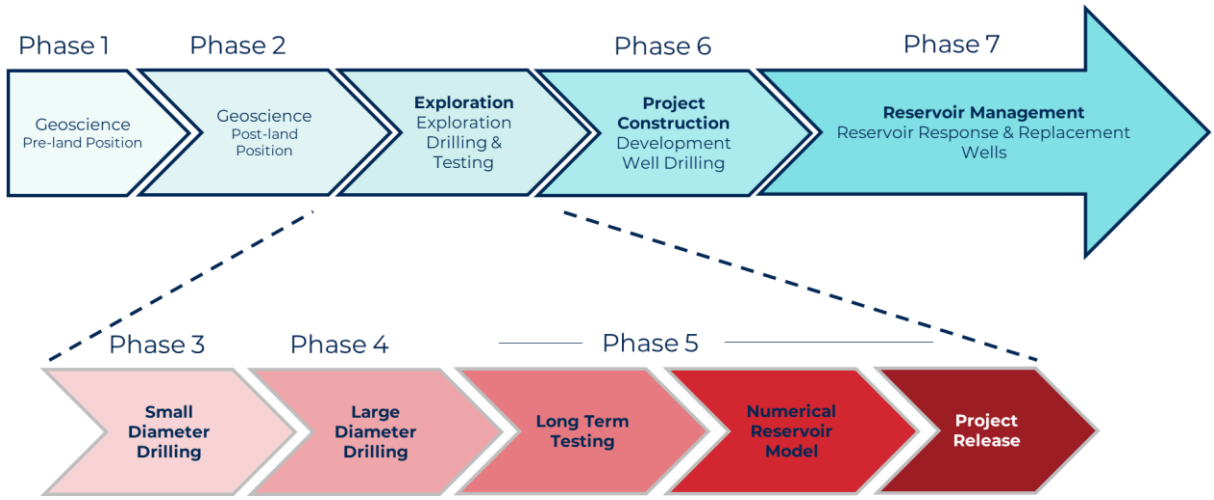


Figure 3: Ormat Phases of Development (Reproduced from Webbison et al., 2026)

The specific usage of reservoir modeling in each phase is described below and summarized in Figure 8 and Figure 9.

3.1 Phase 4 (Full-Size Drilling)

Reservoir modeling is initiated at the start of Phase 4, the beginning of full-size drilling. Inputs at this stage are equilibrated temperature/pressure from Phase 3 slim well drilling and the geologic conceptual model. As described in Webbison et al. (2026), small-diameter wells are used at Ormat to delineate temperature, intersect structures, and monitor reservoir pressure throughout Phase 4 drilling.

The use of vibrating wire piezometers in slim wells has enhanced the value of slim wells as reservoir engineering tools during full-size drilling, collecting pressure interference data throughout the drilling process (at the onset of fluid losses downhole or fluid production through air drilling). A short-term test, generally 4-8 hours with the rig on the well, is the preferred test to quantify individual well potential. Monitoring data collected before, during and after these short tests provides sufficient pressure interference data to calibrate a useful reservoir model.

Through experience, Ormat's exploration process does not use reservoir models to determine specific well targets for two reasons: Firstly, the resolution of geologic heterogeneity is on a scale below a typical reservoir model. For example, the reservoir model grid blocks range from 25 to 100 m horizontal resolution compared to permeability controls, such as feedzones, which may have thickness in the range of <0.1-10 meters. Secondly, the modeling effort in Phase 4 lacks sufficient reservoir engineering data to meaningfully deviate from the geologic conceptual model. The disciplines of geology and geophysics (with geochemistry input where appropriate), guide a comprehensive subsurface conceptual model at a resolution appropriate for well targeting, which is greatly simplified for the reservoir model (see Figure 2).

The value of a Phase 4 reservoir model at Ormat is increased through the collection of specific reservoir engineering data from Phase 3 small-diameter wells:

- Injection tests on small-diameter wells to quantify permeability, generally limited in flow by the casing size
- Heat-up pressure/temperature surveys at 7, 30, and 90 days (plus additional as needed) to measure or estimate equilibrated temperatures
- Instrumentation with high resolution pressure sensors (typically Geokon HT-4500 vibrating wire piezometers) which observe pressure interference responses <0.01 bar and allow for real-time monitoring through cellular or satellite connectivity

An example of pressure monitoring small-diameter wells during full-size drilling is shown in Figure 5, with responses observed during fluid losses while drilling ranging from 20 to 200 kg/s.

Despite limited calibration data, a Phase 4 reservoir model can still deliver meaningful predictive insight when applied within appropriate bounds. A typical use case involves the exploration team defining a set of candidate

injection strategies. The model is calibrated to available slim-hole pressure data near these targets and used to forecast the performance of each proposed production–injection configuration over the life of the field. This enables screening and ranking of options while informing exploration planning. At this stage, uncertainty in the conceptual model is captured through a range of permeability realizations and development scenarios.

An additional benefit in Phase 4 is feedback to the geological conceptual model (Figure 8). The calibration to natural state temperatures and pressure responses while drilling/testing provides an iterative test of the conceptual model against real physics of fluid flow and thermodynamics and helps to narrow down which permeable pathways are more or less likely to control the geothermal system.

Finally, a significant motivator for Phase 4 modeling is to increase a project's speed to market. If a field is to be developed at pace, the reservoir model should be developed ahead of the receipt of data to allow for rapid updates, calibration, and forecasting ahead of the decision to build a power plant. In Phase 4, the reservoir model will have a preliminary external review, typically consisting of a presentation of the available data and initial model, seeking input on the model construction and the recommendation to move into Phase 5 (long-term testing).

Due to the limited data available for calibration, early-stage projections of project capacity rely primarily on analogs and volumetric estimates (as described in Libbey and Murphy, 2026). At this stage, these analog-based methods are weighted at approximately two-thirds, with numerical model predictions comprising the remaining one-third. Following the Phase 5 long-term test and subsequent model update, the weighting shifts, with the calibrated reservoir model carrying greater influence (~2/3) and analog methods reduced to ~1/3. After approximately two years of full operations, the Phase 7 reservoir model becomes the primary predictive tool (~85%) and begins to serve as an analog reference for the volumetric method. However, volumetric estimates remain an important secondary input (~15% in operations) and will be weighted more highly in fields which are undeveloped (e.g. there has been no temperature breakthrough to calibrate to). Figure 4 illustrates this integrated, parallel approach to applying these methods across project phases.

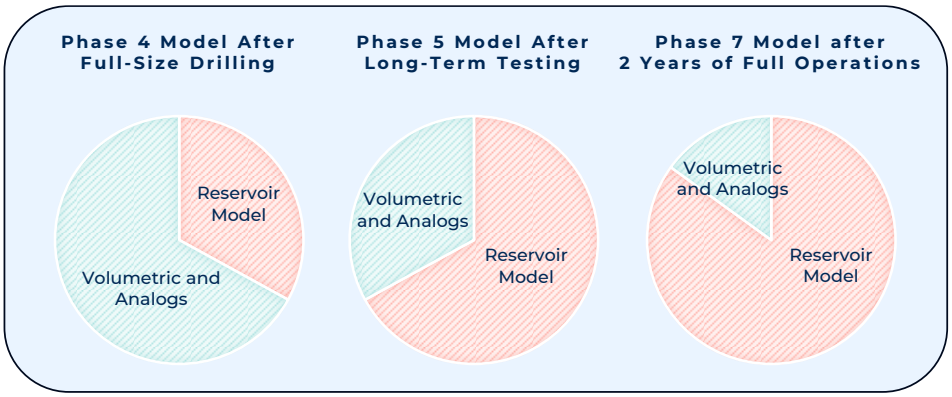


Figure 4: Progression of Reservoir Model Usage by Phase

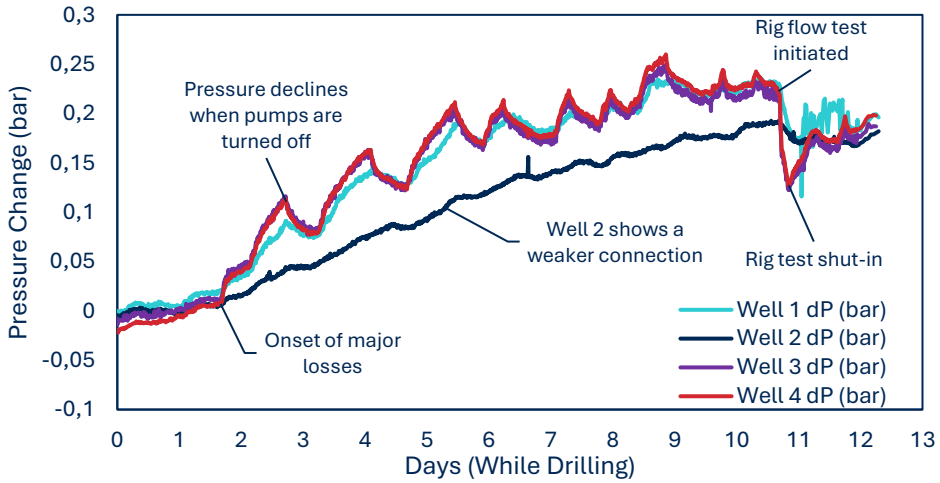


Figure 5: Example Pressure Monitoring Response During Drilling (Discrete Permeability System)

3.2 Phase 5 (Long-Term Testing)

After full-size drilling, Ormat conducts a long-term test of 60-90 days, with a minimum of one production well, one injection well, and one monitoring well. The target for flow is 20 to 33% of the flow rate target for full operations. Durations and flow percentages across 17 long-term tests are shown in Figure 6 and Figure 7, the study of which informs the targeted values for Ormat's long-term tests.

Long-term testing is important for several reasons, primarily to confirm results of short-term tests, or observe changes in behavior due to reservoir permeability barriers. For reservoir modeling, an important part of testing is an extended period (days to weeks) without reinjection to generate a pressure response in the monitoring network. This period of no reinjection is a critical calibration point for Phase 5 reservoir modeling, as it supports calibration of reservoir boundaries, recharge, and differentiate the reservoir pressure behavior with and without injection. Reservoir tracer testing during a long-term test serves to de-risk short-circuiting of injection to production, but due to the low flow rates and short duration, tracer may not be recovered (as seen in the Tungsten Mountain case study in Section 6). The value of reservoir tracer testing in long-term testing depends on the permeability regime and expected tracer return times (Libbey and Murphy, 2026). A reservoir tracer test is recommended in discrete and limited distributed permeability regimes (faster returns) but may be less useful in enhanced distributed or stratigraphic systems, depending on well spacing (Murphy and Libbey, 2026).

Within three months of the conclusion of the Phase 5 long-term test, Ormat's goal is to have a calibrated reservoir model supporting the planned development. This reservoir model is a key input to the Resource Design Point recommendation, constraining the feasible flow rates and forecasted long-term flow, enthalpy, and pressure of the field. This design point is developed iteratively, factoring in engineering design of the generating facilities, wellfield layout, and project economics to arrive on an optimum design.

Forecasting for Phase 5 models encapsulates a probabilistic range of parameters, but is ultimately a single, calibrated model which matches the available data and represents the refined conceptual model. The parameters which are assessed probabilistically are those which are least constrained from the 60-90 day test and have a large impact on the forecast: fracture spacing, the ratio of horizontal to vertical permeability in faults, the strength of boundary recharge, and the permeability of uncertain structures. Ormat's approach differs from some more generalized probabilistic approaches using simplified models, a tool Ormat is evaluating as a supplement to current Phase 5 modeling (Parini and Riedel, 2000).

Although the model is deterministic, it is supported by analog predictions of field capacity. Analogs are applied in a fully probabilistic approach (akin to volumetric heat-in-place), and the proposed development should not significantly exceed the predicted capacity from this analog estimate. The limitations of the reservoir model, specifically the uncertainty of the connection between producers/injectors and uncertainty regarding the response of field margins to full-production are significant, and overreliance on the model despite this lack of "critical data" for prediction would be an error (Coats, 1969). Per Figure 4, above, the Phase 5 model is weighted approximately 2/3 at this stage whereas volumetric methods are weighted approximately 1/3.

Decades of geothermal development at Ormat and elsewhere have shown the value of phased development. Fields such Ormesa (Sonnelitter and Krieger, 2000), McGinness Hills (Lovekin et al., 2016, Akerley et al., 2018), San Emidio, Tungsten Mountain (Delwiche et al., 2018), Heber, Mammoth, Olkaria (Owens et al., 2015), and Steamboat (Dhakal et al., 2025) have had two or more stages of development, with substantial increases in flow at each stage. Within this strategy, the Phase 5 recommendation for larger fields may represent less than half the anticipated capacity of the field, striking a balance between an economic first phase development and the ability to more optimally develop the field in the long-run.

External review from a reservoir modeling expert is an important milestone in Phase 5 modeling, generally consisting of several presentations on the calibrated model, sharing of detailed model information and reports, resulting in a written report from the external reviewer capturing their recommendations and the suitability of the model for forecasting.

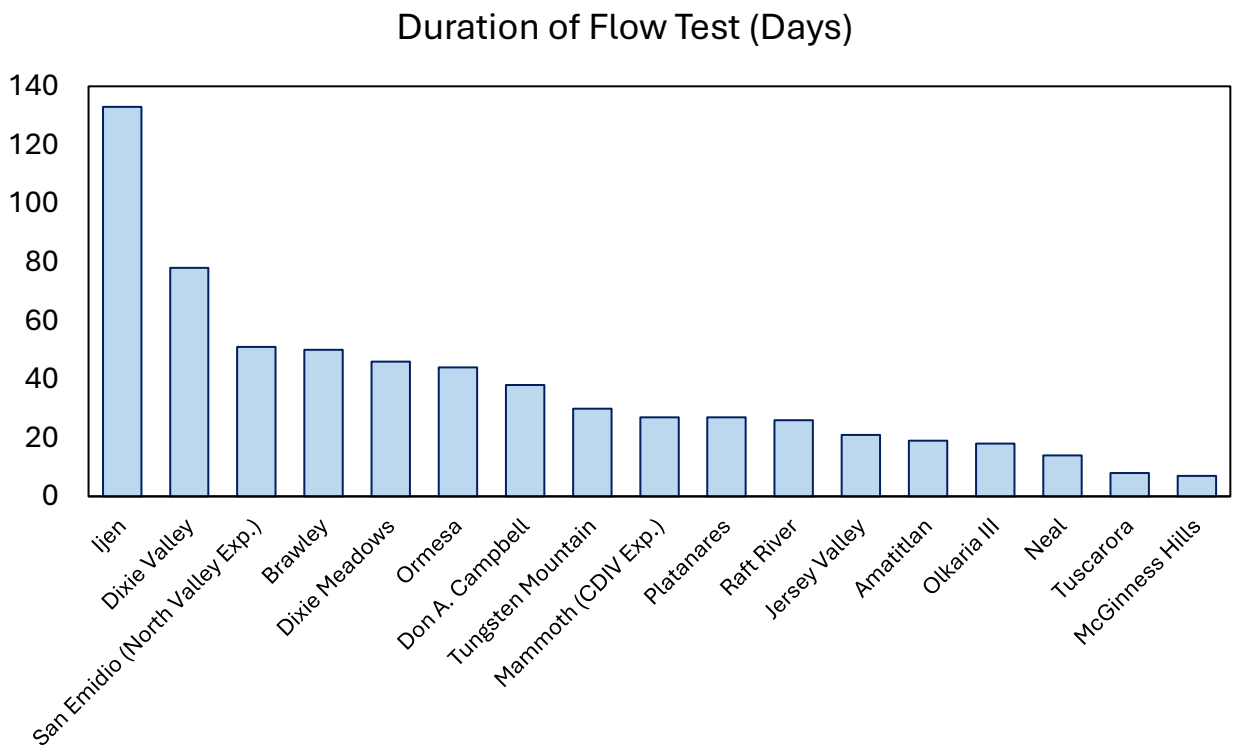


Figure 6: Long-Term Flow Test Durations Prior to First Development (or Expansion as noted)

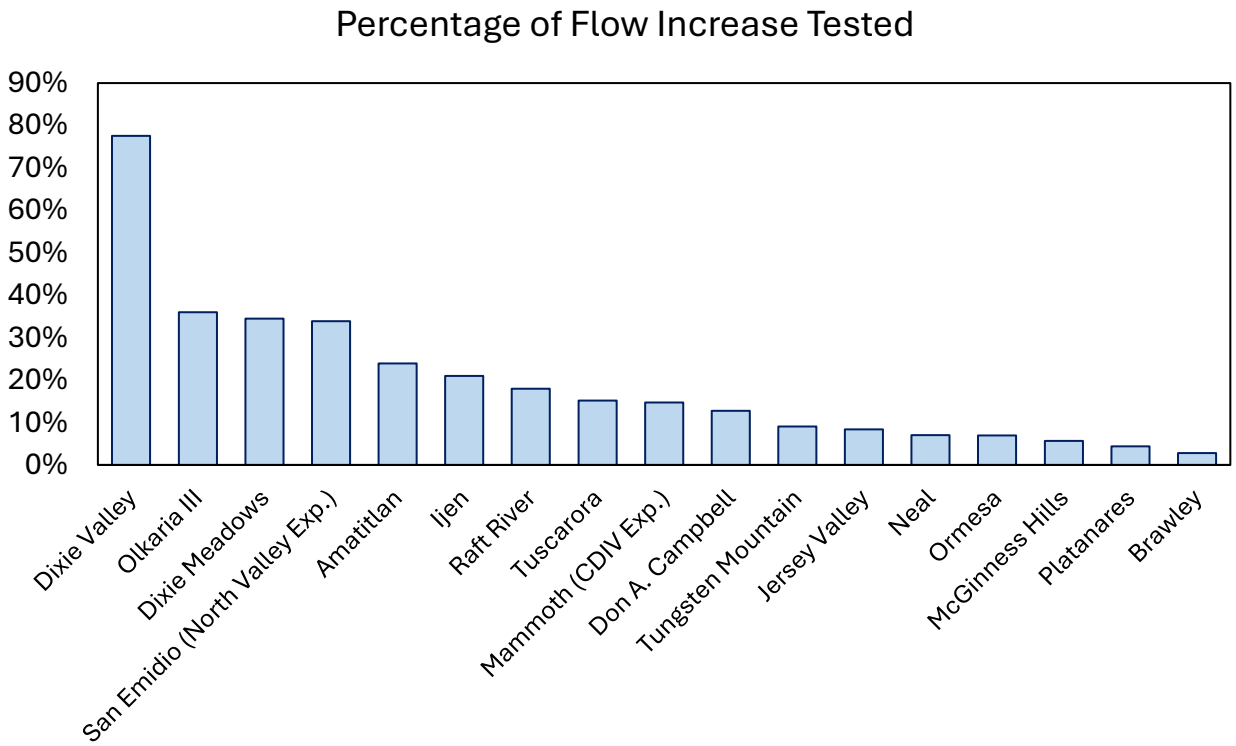


Figure 7: Percentage of Flow Increase that was Tested during Long-Term Testing (Long-Term Test Flow divided by Flow Increase After Test)

Reservoir Modeling for Operational Fields (Phase 7)

Within the first two years of full operation of a new development or expansion, Ormat conducts a full reservoir model update. This model is used to inform expansion potential or identify factors for decline which can be mitigated through re-optimizing operations or additional drilling. The two-year operational mark is chosen because of the specific additional data which is gathered to constrain a significantly better calibrated model after plant startup:

- Results of development (Phase 6) drilling have informed an update to the geologic conceptual model
- A reservoir tracer test is initiated three to six months after plant startup. At full operations, the data from the reservoir tracer test constrains the fluid return pathways from injection to production.
- Early evolution of two-phase enthalpy in high enthalpy systems and observations of initial temperature decline in liquid-enthalpy systems.
- The reservoir pressure response to full production configuration and observations of long-term decline. This can be well predicted prior to startup but is confirmed after full production/injection.

After the conclusion of this major update, two steps are taken:

1. An updated reservoir forecast, including recommendations for expansion or optimization depending on the predicted field performance
2. Bringing the model into Ormat's quarterly update process

Operating field reservoir models are run through a mostly automated process each quarter. Production rates (if pumped), injection rates, and wellhead pressure data (inputs to the model) are updated in the model files and the simulation is run through the history match period and extended using anticipated as-is conditions through the forecast duration. A set of calibration plots (temperature/enthalpy, pressure, and flow vs time) are generated and reviewed with the modeling team and relevant team members to assess the calibration quality and implications for operations.

This quarterly update process has several benefits for operating fields. For the modeling process, the assessment of calibration quality informs if the actual field behavior is aligned with expectations, or if expectations should be revised. Modeling team priorities are adjusted based on the operating field needs and any mismatch noted during this process. The quarterly update also supports the monitoring of each operating field, ensuring that critical data is collected and managed and provides a forum for reviewing operating field data with a reservoir lens,

An important part of geothermal operations is forecasting for budgetary and reporting purposes, which Ormat performs annually as a one-year lookahead. For operating fields with no major planned changes to wellfield configuration or total flow, an analytical, data-driven forecast for the year ahead is the primary budgeting tool. For liquid-enthalpy fields, a linear forecast of temperature decline is often the most reliable short-term prediction of performance. If pressure decline is occurring, this will also assume a linear trend after the field has stabilized. Aspects of wellfield performance such as scaling must also be accounted for in the annual forecast and are outside the scope of the reservoir model. Reservoir models play a larger role in budgeting if a major change in flow is anticipated or has recently occurred, using the model to predict the transition and stabilization after the change.

Phase 7 models are externally reviewed, the depth of which depends on the next steps for the field. In the case of a recommended expansion, a detailed review is undertaken (similar to Phase 5), resulting in a written report from the external reviewer. If no major changes to flow or configuration are proposed, the review will be less formal. After five years of operations, the field will undergo an update to the conceptual model and a subsequent model update.

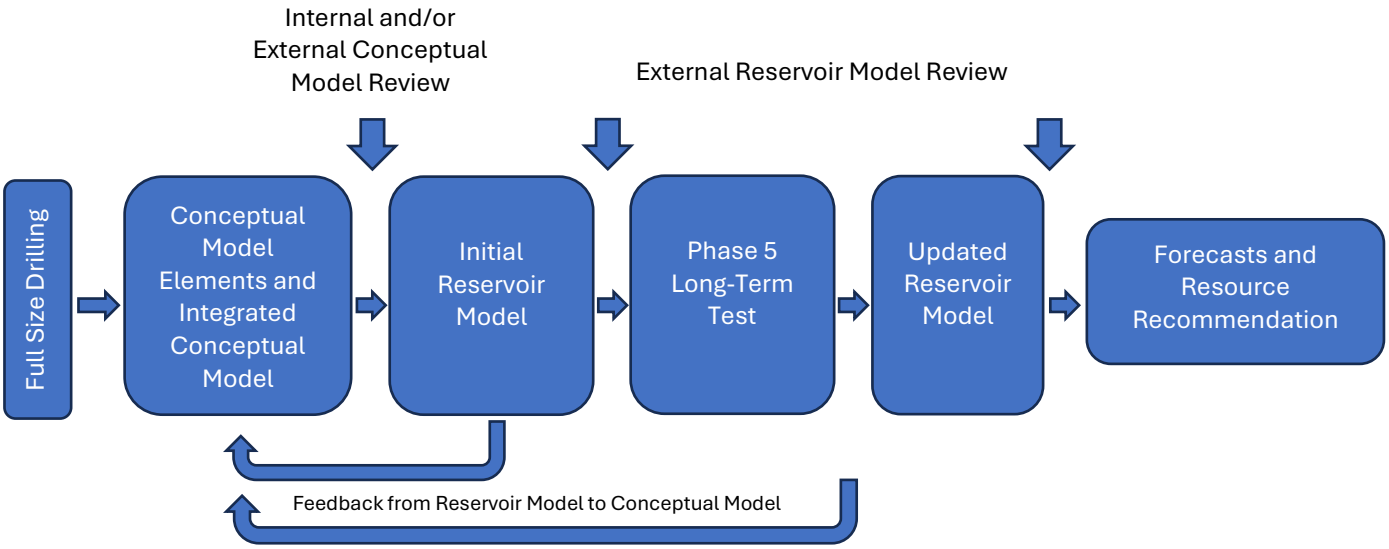


Figure 8: Reservoir Modeling Workflow during Exploration

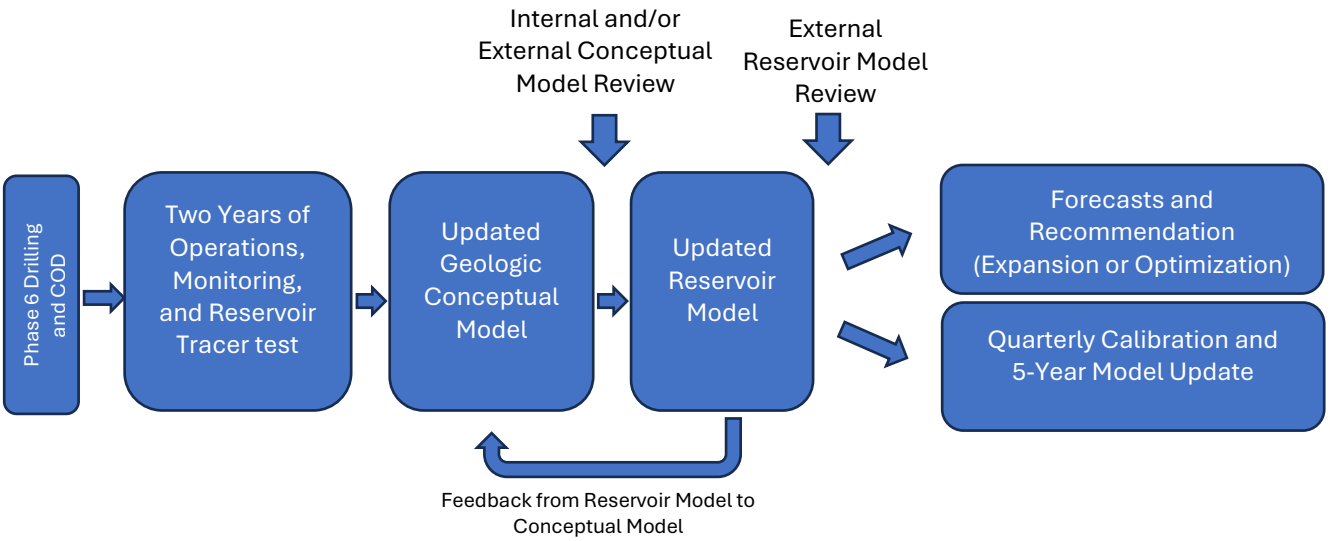


Figure 9: Reservoir Modeling Workflow during Operations

4 ERRORS, UNCERTAINTY, AND BIAS

The limitations of reservoir modeling are succinctly summarized by Coats (1969), who acknowledges that a "true reservoir description is virtually never known", but "the best method of obtaining a valid reservoir description is to determine...the particular description that results in the best agreement between calculated and observed field performance". As such the calibration process to available data is the primary task of the reservoir modeler.

Ma (2010) further defines sources of error in reservoir characterization, some of which are of critical importance to geothermal reservoir modeling. Two are highlighted below.

- The choice of geologic conceptual model has significant implications for the forecast. Lending permeability to lithologies (a stratigraphic model) can have a much more favorable development forecast than if that permeability is limited to a single fracture. In fault-dominated systems, the existence of a single short-circuiting structure can significantly change the forecast, and the reservoir modeler must be mindful of these uncertainties. This error type is analogous to the defined "conceptual errors" and "Errors caused by mixing incompatible reference classes" although the specific errors related to geostatistical extrapolation are less relevant in most geothermal conceptual

models.

- "Observation" and "Interpretation Errors", which relate to the choice and interpretation of calibration data for a reservoir model. An example is the use of downhole temperature surveys, which must be corrected for equilibration after drilling/testing and for inter-wellbore flows. A first-order error is to simply use the raw data without correction, which is avoidable by using only interpreted surveys for calibration. A second is to misinterpret and mis-correct the data; while not avoidable, performing interpretations in the context of a geologic conceptual model and ensuring that interpretations are spatially consistent across multiple wells helps to reduce the interpretation error in temperature surveys.

  Other examples of potential interpretation errors include corrections for diurnal pressure fluctuations or leaks (common in capillary tubing monitoring), and interpreting wellbore effects (such as a casing leak, cross-flow, or scale deposition) as a reservoir effect. Performing adequate quality control on input calibration data is a critical step in reservoir modeling and should be done systematically. Ormat's systems for data management, discussed below, aid in reducing such errors by storing interpretated data for consistent access.

The influence of bias on reservoir modeling cannot be neglected. Lovallo and Kahneman (2003) observe a systematic overoptimism related to "cognitive biases…and to organizational pressures", specifically as it relates to forecasting, which is the primary function of a reservoir model. They recommend the use of reference classes (Kanneman and Tsversky 1979); Ormat heavily relies on operating field analogs as a reference class to supplement and inform reservoir model forecasts. As described above, analog-driven predictions are weighted heavily against reservoir model predictions in the pre-development phases, with appropriate analogs being selected based on reservoir type and normalized against reservoir size (Libbey and Murphy, 2026).

External reviewers are an essential component of avoiding bias, and Ormat employs external reviewers at key points in the modeling process. We have found that external reviewers contribute in three primary ways:

1. Identifying appropriate reservoir analogs which may not be well known to Ormat personnel and providing an outside perspective on the overall conceptual and reservoir model
2. Challenging Ormat's interpretation of raw data, thereby avoiding the Interpretation Error described above
3. Identifying and implementing modeling best practices through their practical experience, in particular good use of modeling conventions which may be unconstrained by data but can influence a forecast, in particular:
    a. Boundary conditions
    b. Permeability magnitudes
    c. Wellbore simulation assumptions
    d. Dual porosity formulations
    e. Acceptable goodness-of-fit
4. Identifying sensitivities and uncertainties which can impact forecasting and warrant further testing

Lovell and Kanneman warn in-particular of bias related to internal expertise. Although Ormat operates fields across a wide range of geologic and enthalpy settings, the majority of Ormat's operating fields are low-enthalpy, single-phase, with 100% reinjection and relatively benign fluid chemistry. As such, our analog reference and calibration for liquid-phase enthalpy decline related to injection returns is very strong, but we must be cautious of an optimistic bias (and perhaps blind spots), related to (e.g.) marginal recharge incursion related to long-term pressure decline or transient behavior of two-phase zones in high-enthalpy systems.

The system represented by a reservoir model (defined above) also explicitly neglects some elements of potential reservoir changes (e.g. scale deposition, thermal stimulation of fractured rock), and the modeler must be conscious of the limitations of their forecasting tool. Even within the physics represented by a reservoir model, the model may be limited in predicting some aspects of reservoir performance, as the model is tasked with calibration to and representation of all available data as well as maintaining a reasonable agreement with the geologic conceptual model. If, i.e., the pressure transient match to a reservoir stress test is of poor quality in an

otherwise reliable model, the modeler should supplement their forecast with an analytical or process model when the reservoir pressure forecast is of primary concern.

5 DATA SYSTEMS AND AUTOMATION

To maintain the desired standards of calibration and frequency of updates on 30 operating fields and multiple active exploration campaigns, automation and data management tools have been developed at Ormat to efficiently run, update, and calibrate numerical models with the most current data.

All calibration data for reservoir models is stored in SQL databases, including daily operating data, monitoring pressure data, well test observations, periodic measurements (e.g. TFT and downhole PTS surveys), and reservoir tracer test results. Additionally, input parameters such as well location and trajectories, and completion data are stored in databases that allow for automatic model updates and visualization. These databases support a philosophy of data democratization and are linked to visualization tools accessible to all Ormat employees. Improvement and expansion of these visualizations is an ongoing priority.

Calibration plotting and quarterly updates for numerical models are conducted through pre- and post-processing codes which directly edit the reservoir model files, input operating data, and query simulation results to generate standard plots of key calibrations.

The automation tools developed at Ormat are designed to function with Volsung models and leverage scripts developed by the Volsung developers for querying simulation files.

6 CASE STUDY: TUNGSTEN MOUNTAIN

A brief case study of the Tungsten Mountain development is provided to illustrate Ormat's numerical modeling process. The Tungsten Mountain field was initially delineated through several slim wells which encountered high temperature and permeable structures. An initial test of seven days utilized one full size well for monitoring while discharging a slim well without reinjection. The full size well was subsequently flowed for 30 days with injection to the slim well and an NDS tracer was injected. The measured data showed a strong pressure communication between the two wells indicating a highly permeable connection, however, no tracer was recovered. On the basis of these data, a Phase 5 model was completed and an initial development of 26 MW was released and came online in late 2017. A moderate temperature decline was forecasted at this time, and a small pressure decline followed by stable pressure.

A reservoir tracer test was conducted shortly after plant startup, which supported and augmented the conceptual model permeability pathways. Although no tracer was recovered during the long-term test, wells with the same feedzones did show a connection during full operations, with first returns at 21 days. The faster return time relative to the long-term test is attributed to higher overall fluid throughput, a larger reservoir pressure change, and therefore higher velocity and less dispersion. A second tracer test was conducted in 2019. Operations continued into 2020, at which point the observed cooling was less than Phase 5 model prediction. The wellfield configuration was somewhat different than the Phase 5 forecast, due to successful development wells (Phase 6) which allowed for distributing both injection and production over a larger area. On the basis of three years of operating data with favorable temperature decline and the reservoir tracer test, the reservoir model was significantly updated. Changes to the permeability structure were required to match both the tracer results and cooling observations, which showed that more reservoir volume was being swept from injection to production than was predicted in Phase 5. This numerical model confirmed expansion potential for Tungsten Mountain, an expansion which utilized additional surface equipment (including injection booster pumps), but no new wells. The expansion came online in 2023, bringing total capacity to 41 MW. The pre-expansion model reasonably predicted the temperature decline after expansion, but further improvements were warranted, and in 2023/2024 the model underwent a revision and software conversion, incorporating a third tracer test and further observations of cooling on an individual well basis. At present the Tungsten Mountain model is maintained through quarterly updates and informs adjustments to the operating strategy.

7 STATUS CHECK AND FORWARD LOOK

As of January 2026, 16 of 30 operating fields are in updated Volsung format. Seven models are in legacy formats and require a more manual update process; these models are planned to be converted to Volsung for consistency with the Ormat process. Four operating fields do not have calibrated reservoir models; either recent acquisitions by Ormat or stable operating fields, all which are planned for future modeling. Three models are maintained by joint venture partners or consultants for those joint ventures with review and support from Ormat.

The Ormat reservoir modeling workflow outlined in this paper has been developed over several years of growing an internal reservoir modeling team. Some enhancements to the modeling process are underway or under consideration. Sensitivity/uncertainty testing is currently limited to select parameters of high impact, but models are effectively deterministic models. The use of more simplified numerical models and testing large parameter spaces for use during exploration (Phase 4/Phase 5) to supplement the deterministic model is being evaluated.

Ormat currently does not utilize automatic history matching in modeling and has found limited practical value in implementing this, recently testing PEST for improving model matches. Ormat would benefit significantly from improved automation of the history match process after a model has been largely calibrated, which may be enabled by recent advances in artificial intelligence. Similarly, Ormat has engaged with research developing machine learning proxy models based on reservoir models, but has not implemented this internally (Beckers et al., 2021). Ormat has supported efforts to integrate geomechanical models with reservoir models but has only implemented this internally in limited cases. This choice reflects our successful modeling and forecasting of conventional hydrothermal systems without explicit geomechanical physics, whereas geomechanical modeling is critical for enhanced geothermal systems utilizing hydraulic fracturing.

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