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SW CPDEP, PROJECT MANAGEMENT PROCESS FOR THE RIGHT DECISION FOR DRILLING AND COMPLETION IN GEOTHERMAL

Panurach Dumrongthai, Drilling Engineering Manager
Riza G. Pasikki, Senior Reservoir engineer

Chevron Geothermal Indonesia
26 floor , Sentral Senayan II, Ji. Asia-Afrika, Jakarta
e-mail: dumr@chevron.com , RPCB@chevron.com

ABSTRACT

Drilling wells is probably one of the highest capital expenditure, and highest risk for geothermal industries today, starting from exploration, delineation, initial wells for production and infill when an existing wells production are declined. It is estimating cost of 3-15 MM $ for drilling new wells for geothermal industry today, which is required a high level of decision making from high level of management.
To make the right decision on spending a high capital expenditure on drilling require multi principle workforce, such as Drilling engineer, Geologist, production engineer, Reservoir engineer, Drilling side manager , etc. to planning ,design wells, and execution. Many time, the group of work force has conflict on their own objective, such as geologist required to know information, reservoir engineer required to maximize production rate and drilling engineer required to lower well cost. Challenge for decision maker is always on how to compromise between working team and making the right decision.

This paper will illustrate the process and methodology of Project management process which **Chevron Geothermal Indonesia used for the right decision making**. The result has proven success of 2012-2013 Salak Drilling Campaign which is currently estimation of 10-15 million dollars saving from the original plan, steam supply meet requirement, water injection meet requirement which required to drill 2 wells less and plan, and know value of information for decision of new PAD location will b construction for future infill wells.

BACKGROUND

Salak 2012-2013 Drilling campaign team has start planning process since June 2011. Base on mid-term business planning (5 years), it was required to complete the first production from infill drilling wells and put on production before end of 2012. In generally, practice is to starting infill wells drill campaign 6 months, prior steam supply shortage.

The working team starts working since mid 2011 thru "CPDEP" which is Chevron Project development and Execution Process and proposes to management in November 2011. The missions of the drilling campaign are:

1. To maintain 377 Mw generation until 2016
2. To supply 2000 KPH wells capacity for Brine outfield injection project.
3. To completed work over jobs to maintain well integrity for existing wells
4. Completed project within budget and schedule.

The working team which consists of Reservoir engineering, Drilling, Geologist, Facility Engineer and all other support department consider well target from many location and choose wells into portfolio. The proposal to management and get approval are as followed:

1. To drill selected 9 Steam make up wells to maintain 377 Mw generation until Q2 of 2017 (NOTE: planning next drilling campaign in Salak , start in Q3 2016)
2. To drill 4 outfield injector wells at 2000 KPH capacity, support brine outfield project, includes stimulation. (To remove hot brine production and inject out of hot reservoir)
3. Completed 2 work over to maintain well integrity.
4. Test new technology for electric submersible pump.

The total cost estimation, base on previous well performance in Salak Drilling campaign in year 2007 to 2009 indicated of 570 days of operation and required 99.5 MM $ for this campaign. Project anticipation start date on 1 April 2012 until end of October 2013.

CPDEP - CHEVRON PROJECT DEVELOPMENT AND EXECUTION PROCESS

Chevron develops CPDEP process for being used as project management system for planning, design and execution of project. It is wildly and commonly use in most of either major or small capital project within Chevron Corporation. The CPDEP is composed of 5 phase which is indentified as followed:

Phase 1: Identify and assess opportunity
Phase 2: Generate and select alternative
Phase 3: Develop preferred alternative
Phase 4: Execute
Phase 5: Operate and Evaluate

SWCPDEP FOR GEOTHERMAL OPERATION – SINGLE WELL CHEVRON PROJECT DEVELOPMENT AND EXECUTION PROCESS

Chevron Global Drilling and Completion group which is locate in Houston head office develop project management process for being used for drilling and completion in Chevron operated business unit. Scope for all drilling and completion around the world , such as Deep water drilling operation, offshore, land oil and gas, shale gas, exploration and also with Geothermal Business Unit.

The Single Well CPDEP Standard Operating Procedure is designed to provide the minimum requirements for project management when planning and executing a single well or group of wells for Chevron Geothermal Operations in Indonesia or Philippines.

The Well Decision team (WDT) will be selected from multi-principle workforce which is Drilling Engineer, Geologist, Reservoir Engineer and Facility Engineer, by support of other function. The team has objective to design, execution and look back for single or group of drilling and completion wells to support main objective from Salak 2012-2013 team. For example, the Well Decision team for AWI 10-1 will be ensures the well deliver amount of steam as one of the 9 infill wells.

The objectives of this Standard include:

- Establishment of a well communicated and understood well planning process.
- A project timeline that identifies the chronology for successful well planning and execution activities.
- Use of integrated multifunctional Asset / Project team (Well Decision Team, or WDT).
- Ensure timely input for optimal communication and collaboration and to avoid rework.
- Standardized work processes to technically mature wells and identify other applicable Global Standards and processes.
- Assure the Decision Review Board that a single process is being used consistently to identify, mature and execute drilling prospects.

The process has 5 phases which has critical key activity as followed:

Phase 1: Identify and assess opportunity

The WDT (well decision team) start grouping and work on critical action item as followed:

Develop business case- well objective, and strategy Team member will identify project type and scope:

- Steam make up well : Set an expectation of steam make up initial production rate, project NPV and DPI, additional steam make up for power plane number.
- Injection well : Identify potiential of injection rate (in KPH) , project economic.
- Exploration or delineation well: Clearly identify project Value of Information.
- Work over and well intervention:Identify reason for work over required, either improving production rate, fix well problem or safety reason.

Project Framing- Indicate keys activity, and decision team will have to work and make in future phase. Also clear objective for issue will not be discussed by put them out of frame.

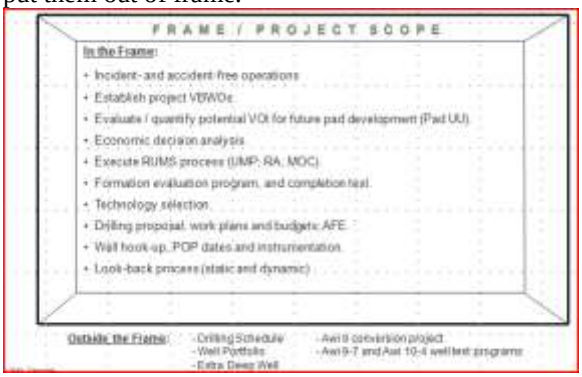

Figure 1: Illustration a sample of project framing

Decision Hierarchy- Identify issue which can or cannot control. This is compose of three level:

1. Given – for issue which is lock down or cannot control from WDT. Such as PAD location (due to WDT is assign to drill well from specific PAD base on assignment from Salak infill team), or Drilling rig which has been sign for long term contract.
2. Strategic Focus- issue which will be a critical discussion as alternative.
3. Tactical Decision – any issue which is not important for key decision which can be discuss in phase 3, such as bit selection

Figure 2: Illustration a decision hierarchy

Team will use phase 1 cost estimation (+/- 30 % error) and initial economic and send the decision support package to DE (decision executive) and DRB (decision review board) who are the committee making decision to either move into next phase or feed back to WDT team for re consider for additional work. In general, phase 1 will be end approximately 2-3 month prior execution phase (Phase 4)

Phase 2: Generate and select alternative

In general, phase 2 consume most of time, meeting and discussion. After DE/DRB endorse WDT move into phase 2. Team will start working on critical meeting and issue as followed:

Value Based Well Objectives (VBWO) - The main objective of VBWO is to ensure working team set up team goal and objective of project base on business required. For example, the high priority for steam make up well is the best economic. Which is not always maximizing production rate. Also not the cheapest drilling cost. For the VOI well, team has to identify the value of knowing information in money value, such as exploration well, the value of well information can help saving or potential of future field development.
The objective set with "SMART", meaning Specific, Measurable, Achievable, Relevant and Timely. Working team set project objective together, and individual function will set own objective to support team objective. However, if there any finding on conflict, the team will solve in earlier phase.

Uncertainty Management plan (UMP) – propose of UMP is to identify key subsurface and operation uncertainties and to develop work plans to lower the associated ranges of these uncertainty that impact well construction risk. Team will brainstorm issue s and categorize as decision and uncertainties. Categorized are as followed:

Decision – The available choices or actions that can be controlled.
Uncertainties – Factor that cannot be controlled.
Value Drivers – Metrics used to compare and rank alternative.
Other – Facts or process issues

The uncertainties ranges will be consider and team will solve the big factor which could have a big potential impact to VBWO.

Strategy Table

Team will brainstorm and create alternative, base on strategy focus. The Strategy Table will be used for select a prefer alternative.

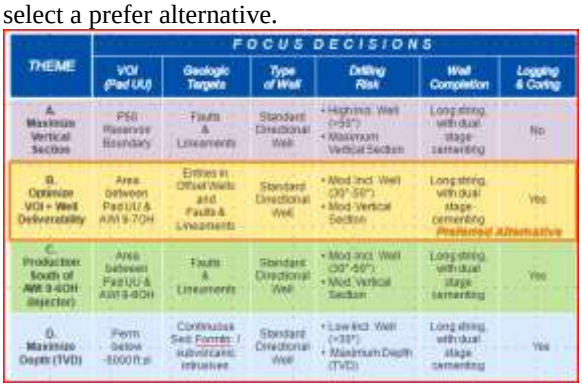

Figure 3: Illustration a Strategy Table

Risk Assessment of Alternative

For each alternative, team will preliminary access risk which could potentially effect to VBWO. Each alternative will be doable and realistic. However, if there is any finding of high risk from some alternative, team will consider not to propose as a prefer alternative.

Project Economic

The Cost estimation, NPV and DPI will be evaluated for each alternative. Usually, the prefer alternative will be chosen base on the best DPI. The VOI value will be indentify and also be a part of economic evaluation.

Selected a prefer alternative

Project team member will rank each factor which effect for selected a prefer alternative. Such as Economic, potential steam supply, VOI, VC (value

creation),Drilling Risk, or Drilling cost. The prefers alternative will be proposed to Decision committee.

DE/DRB Phase gate meting

WDT team will prepare DSP (Decision Support package approximately 1 week, prior meeting. The review and approval committee is composing of:

Decision Executive (DE) – the chair person who make the final Decision
Decision Review Board (DRB) – the committee who assist DE for review DSP and make decision as a group of committee.

WDT team usually schedule with each DE/DRB for snaking meeting prior DE/DRB phase gate, to ensure each committee member have review DSP and can give feedback prior the phase gate meeting. The quality of DSP will be evaluated by using **"Decision Quality Tools (DQ)"** which has six elements.

- Appropriate Frame
- Create Doable Alternatives
- Meaningful and Reliable Information
- Clear Values and Trade off
- Logically Correct Reasoning
- Commitment to Action

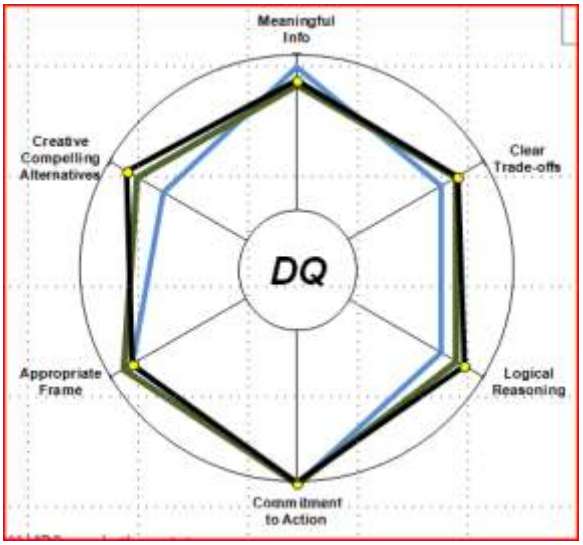

Figure 4: Illustration a Decision Quality

After the phase gate meeting, DE/DRB will approve or recycle project and provide DQ score to team member. Then the project will be move to phase 3.

Phase 3: Develop Preferred Alternative

Phase 3 work scope is to ensure WDT team has align to develop detail work scope and stay focus on an approved prefer alternative only. Critical issue for phase 3 are as followed:

BOD Lock down

The Basis of Design (BOD) is a document which is required for well construction. Most of important information will be capture and sign by WDT team member and Manager. Such as estimate pressure, temperature, surface location, bottom hole location, etc. The BOD will be lock down at the earlier of phase 3, and used as a commitment between team member for further detain engineering. However, if there are anything require to change from BOD, the team member can ask compete to change thru MOC (Management of Change) process.

Management of Change (MOC)

The propose of MOC process is to identify, access ad document change prior to the change being made. The process start implement for and request to change since phase 3and phase 4. The document will be capture thru MOC form and had to get approval from DRB member, depend on how change being effect to project.

Risk Assessment of a preferred alternative

Risk assessment is a process to identify potential risk which could impact to well construction process, Brainstorm for risk mitigation and taking action item prior execution phase. The meeting will conduct in the earlier of phase 3 by Drilling engineer, WDT team member and business partner. Key factor for phase 3 risk assessment are:

1. Risk Description – Identify potential risk could happen in execution phase.
2. Consequence description – identify what could happen if the risk happen
3. Existing Safe Guard in place – Identify SOP, meeting, procedure , or anything have existing safe guard
4. Consequence type –either HSE or R&E
5. Risk Ranking - put the score which has running number from 1-6 for two categories
   -Likely hood – How many percent of potentially happen
   - Consequence Impact – Number of cost could impact to project if the risk happens

   The team will access Risk ranking to Chevron metric and the score will show either accept or mitigate. If it is required mitigation, team will put action item and identify an additional safe guard required prior an execution phase

6. Risk Assessment approval – the form will be approval and tracking the remaining action item

Detail Well design

Drilling Engineer will perform detail analysis, prepare for drilling procedure. The general detail engineering such as Casing design, torque and drag, mud program, cement program, bit selection, etc. This is to ensure that the well construction designed base on engineering basis. The list of equipment will be communicated to business partner for preparation prior rig on location.

Formation Evaluation Program

Geologist will prepare the final formation evaluation program, such as cutting analysis, logging, coring. And develop detail procedure

Draft and develop Drilling Program

Drilling engineer will draft detail drilling program which will be used as detail procedure for Drilling Superintendent who will be leader on well construction and drill site manager (DSM)

Peer Review

Project drilling engineer will conduct peer review meeting, ask feedback from another engineer, business partner and other WDT team member.

AFE requisition

WDT team member will prepare a drilling proposal which is a document summary of package, such as VBWO, Risk, economic evaluation, well construction design and program, DSP will be submitted for request for fund (AFE) approval from DE/DRB member.

After AFE has been approval, the project will move to phase 4.

Phase 4: Execute

Phase 4 is the time of taking action. The critical work items in phase 4 are as followed:

Drilling Program lock down

The final Drilling program will be lockdown and sign by Drilling Manager. This is to ensure that the detail of well construction procedure has been lock and will be used as material for communication.

Pre-Spud Meeting

WDT team leads by Drilling Engineer will schedule the pre-spud meeting with Drilling Superintendent, DSM, field personal and business partner. This is to ensure that the clear communication has been made between design and execution.

Execution

The Rig, Equipment, field personal will start mobilize and start well construction by follow Drilling program. Daily operation report will be record thru Wellview Database and keep in office. Morning meeting will conduct to ensure a clear communication has been report to office. Superintendent will be a single point of contact between office personnel and field personnel. If new information found during operation and required to change from drilling program, the team will request and submit thru MOC process.

Capture Lesson Learn

DSM will capture lesson learn and put into database, ensure that next project will be planning properly.

Well Hand over

DSM will submit document and hand over well to production person after well completed.

Phase 5: Operated and evaluate

After completed well construction, WDT team will complier all information, such as lesson learn, daily report, database, mud logging data, result of formation evaluation, completion test, flow test. And start look back process.

Evaluation

Team will analysis and evaluate the result of well construction process, such as DVD chart (Day vs depth) , actual cost vs AFE, Steam production vs plan, etc. And conduct look back meeting:

-On Rig side – This is a quick communication to a field personnel to remain lesson learn.
- In Office. Team will fully evaluate the well result thru DE/DRB committee. The result such as cost, production, lesson learn will be compare to the original VBWO for project evaluation

Project Close out

WDT team will propose for close out project after DE/DRB look back meeting has been done.

CASE STUDY

Case A – Drilling two steam cap in PAD A

The Salak Drilling campaign team assigned PAD A WDT team, to study and recommend DE/DRB base on initial goals as followed:

Goal – Drill well to evaluate future potential PAD
-Expect Steam supply 350 KPH

PAD A WDT team works phase by phase:

Phase 1: Identify potential of drilling two steam cap producer wells with approximate +/- 10 MM $ and supply steam > 350 KPH

Phase 2:
VBWO: 1. Incident free
2. DPI > 1.3 (estimate 2.1 from Well A and 2.3 from Well B)
3. Steam production > 350 KPH
4. Evaluate future PAD potential
5. Success evaluation multi-lateral well
6. Cost under AFE

Create Doable alternatives :Team create 6 alternative wells for Well A which has target to able to evaluate future pad potential, plus some steam supply. And 3 alternatives for well B which also included "Multi-Lateral "steam producer. (First time approached in Indonesia)

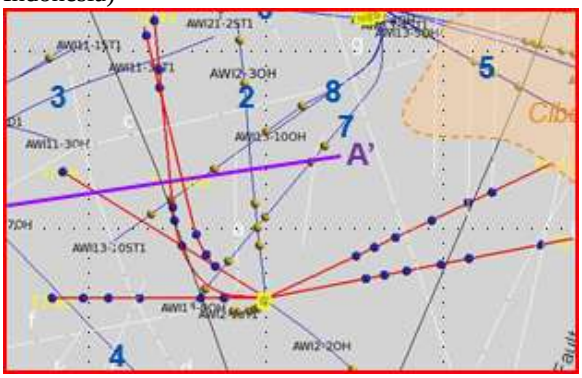

Figure 5: Illustration WDT team creates alternatives prior selected a prefer alternative

Selected a prefer alternative:

1. Drill well AWI A to South East, estimate steam 153 KPH and evaluate VOI for future PAD (DPI 2.3 NPV (9.0 MM)

2. Drill well AWI B with Multi Lateral producer; estimate steam 196 KPH and capture lesson learn for Multi-lateral technique (DPI 2.1 , NPV 8.2 MM)

Phase 3:
Risk Assessment (Key issue) and mitigation:
1. Multi- Lateral Junction collapse: Run Sonic log and identify hard rock
2. Water to kill well drilling drill out junction: Ensure water supply to well > 40 BPM.

Well Design
Well A: 26" x 20" CSG – 1200 feet
17 1/2" x 13 3/8" CSG 2200 feet
12 ¼" x 10 ¾" liner to TD 6000 feet
Well B : 26" x 20" CSG – 1200 feet
17 1/2" x 13 3/8" CSG 2600 feet
First leg 12 ¼" x 10 ¾" 5500 feet
Second leg 12 ¼: x 10 ¾" 5200 feet

Phase 4:
Well A : Drill spud to TD with minimum problem , made TD with 9.1 day since spud.

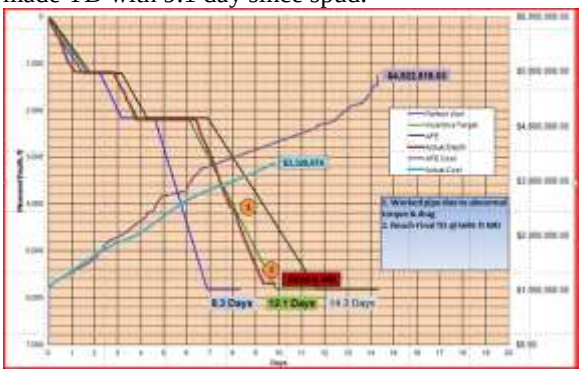

Figure 6: Illustration DVD performance of AWI A

Well B: 1. Drill to 17 ½: by 3 days.
2. Logging Sonic and tools stuck, lost in hole tools, fishing operation and recover fish to 5500'
4. Set plug, wip-stock, drilled side tract in 13 3/8" casing and drill 12 ¼" and run 10 ¾: second leg to 5200 feet. Pull out and recover wip-stock
5. Pump water while drilling out plug and chase plug to TD

Phase 5: Look back base on VBWO

	Plan	Result
Incident Free	zero	Zero
DPI > 1.3	2.2	5.0
Steam rate kph	350	650
Capture Multi-Lateral	Evaluate and recommend for future	Proven technology and will implement and development
Future PAD	Evaluate	Yes, plan construction in 2016
Cost in AFE	10.9 MM	8.3 MM

Case B – Drilling one deep liquid PAD B

Phase 1: Identify potential of drilling one deep liquid producer wells with approximate +/- 6 MM $ and supply steam 190 KPH

Phase 2:
VBWO: 1. Incident free
2. DPI > 1.3
3. Steam production > 195 KPH
4. Hit all target Drill to TD (expect high temperature)
5. Cost under AFE

Create Doable alternatives : Team create 3 alternative – Drill to South West has lower steam but high VOI
-Drill North West maximize KPH but low VOI
-Drill to North has optimize VOI and KPH

Selected a prefer alternative: Team indentify and suggest for maximize Steam. Propose Well A with6.2 MM $ AFE, 195 KPH expect steam rate, Drill TD at 9200 feet.

Phase 3: Well Design
Well A: 26" x 20" CSG – 1800 feet
17 1/2" x 13 3/8" CSG 4200 feet
12 ¼" x 10 ¾" liner to 6800 feet
9 7/8" x 8 ½" liner to TD 9200 feet
Plan to drill to TD by aerated mud

Phase 4: -Moving rig to location, has to stand by Drilling Rig and not ready to spud due to a problem, total move and stand by at 33 days.
-Drill 26" 1200 feet, had high vibration, lost bit and motor, attempted to fish out not success. Plug and side tract well.
-Drill 26" and 17 ½" to 4200 feet, set 133/8" liner and cement.
-Drill 12 ¼" to 6800 as plan, log and run 10 ¾" liner.
- Drill 9 7/8" hole by water due to requested by WDT team , from 6800 to 8150 feet, found high torque. Decided to TD earlier than plan.
- Drill 7 7/8" from 8150 feet to 8850 feet by water, shortening 350 feet from plan due to high torque, miss the last target.

Phase 5: Look back base on VBWO

	Plan	Result
Incident Free	zero	LTA during rig move
DPI > 1.3	1.3	1.02
Steam rate kph	195	14
Hit all target and drill to TD	9200 feet	8850 feet
Cost in AFE	6.2	7.9

Case C – Drilling two Water injection out reservoir field

PAD C is located out of reservoir had 1 existing well with 500 KPH @ 500 psi after drill and stimulation. Had 1 more well with side tract but not stimulation.
Phase 1: Identify potential of drilling 3 more wells to meet another 1500 KPH at 500 psi.

Phase 2:
VBWO: 1. Incident free
2. Success drilling with stimulation with 1500 KPH at 500 psi after stimulation
3. Initial before stimulation > 0.45 kph per psi
4. Cost under AFE

Create Doable alternatives: Team create 4 alternatives to drill West, South West, and two south East (NOTE: 2 of existing wells on north and east).

Selected a prefer alternative: Team suggest to drill two wells on West and south west due to no information. Expect initial injection rate can be lower than estimate, but VOI is high value for making future decision.

Phase 3: Well Design
Well A: 26" x 20" CSG – 2000 feet
-17 1/2" x 13 3/8" CSG 2500 feet
-12 ¼" x 10 ¾" liner to 4000 feet with zonal isolation
- 9 7/8" x 8 ½" liner to6500 feet with zonal isolation
- 7 7/8" x 7" liner to TD at 7200 feet

Well B: 26" x 20" CSG – 2000 feet
-17 1/2" x 13 3/8" CSG 2500 feet
-12 ¼" x 10 ¾" liner to 5200 feet with zonal isolation
- 9 7/8" x 8 ½" liner to7500 feet with zonal isolation
- 7 7/8" x 7" liner to TD at 9200 feet

Phase 4: -Moving rig to location within from 12 days as plan.
Well A:
-Drill 26" run 20" with new cement technology, drill 17 ½" run 13 3/8" and success light weight cement long string (new technology)
-Drill 12 ¼" to 4000 feet , run 10 ¾" and cement for zonal isolation (new technology)
- Drill 9 7/8" to 6800 feet, log and found potential fracture, decided to continue to drill future without cement isolation
- Drill 7 7/8" from 6800 feet to 7200 feet as plan, request MOC to extend to 8500 feet. TD well and move rig to well B.

Well B:
-Drill 26" run 20" with new cement technology, drill 17 ½" run 13 3/8" and success light weight cement long string (new technology)
-Drill 12 ¼" to 5000 feet found un-anticipated lost circulation. Decided to MOC and drill with aerated mud. TD section, log, run liner.
-Drill 9 7/8" to 9200 feet and completed well with total lost circulation

Team Decided to skid rig back to well A and perform stimulation by running packer and stimulation.

Phase 5: Look back base on VBWO

Well A	Plan	Result
Incident Free	zero	zero
Initial Injection rate	0.45	1.03
Under AFE	7.19	6.2
Injection rate at 500 PSI	200	510
Well B	Plan	Result
Incident Free	zero	zero
Initial Injection rate	0.45	3
Under AFE	6.3	5.7
Injection rate at 500 PSI	200	2000

WDT Team did not decided for stimulation, however, base on the result , the project can be close out due to injection capacity of these two well out standing from total 2000 kph of injection. Team recommends to cancel another well from original plan. (NOTE: result of initial injection Well A = 180 KPH @ 500 psi, after stimulation indicate 510 KPH at 500 psi)

SUMMARY RESULT OF SALAK CAMPAIGNE

Steam Make up wells

	Plan	Actual
-well number	9	8
-KPH	2010	1758
-Evaluate future PAD	Evaluate 3 new PAD	Confirm 3 new PAD will be construction
Cost	42.7 MM	36.9
Outlook forecast to end of campaign	377 MW until 2017	377 MW until 2019
-well number	9	11
-KPH	2010	2463
Cost	48.7 MM	51.2 MM

Injector wells

	Plan	Actual
-well number	3 new and 1 work over	2 new and 1 workover and side tract
-KPH	1500	2550
Cost	42.7 MM	36.9

CONCLUSION

1. Selected Multi-principle group as team working, identify clear in/out frame. Set a clear vision in the earlier stage of planning
2. Clear VBWO in earlier phase 2, used conflict resolution if team has conflict in earlier phase.
3. Propose DE/DRB by using snaking session to avoid project re-cycle
4. Close out UMP and Risk Assessment action item to avoid not productive time.
5. Used Engineering and database on well planning
6. Used MOC process to capture changed
7. Make decision if finding change as a group, ensure project deliver as plan.
8. Set up pre-spud meeting ensure field personnel understand procedure and objective
9. Clear communication from field personnel and office personnel in execution phase.
10. Capture information in database
11. Capture lesson learn and using data analysis. Lock back as soon as possible for next project improvement.

NOMENCLATURE

CPDEP - Chevron Project development and Execution Process
Mw - Mega Watt
KPH - Kilo pound per hour
WDT – Well decision team
NPV – Net Present Value
DPI – Discounted Profitable Index
VC - Value Creation
VBWO - Value Base Well Objective
VOI - Value of information
DSP - Decision Support Package
DE - Decision Executive
DRB - Decision Review Board
BOD - Basis of Design
MOC - Management of Change
SOP - Standard Operating Procedure
HSE - Health Safety and Environmental
R&E - reliability and efficiency
AFE -
DVD - Days vs Depth