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# A Low Impact Rigless Well Abandonment Solution for Complex Wells

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## Abstract

Discuss a cost-effective rigless methodology to abandon complex onshore wells.

- Onshore wells can be near housing, and multiple non-technical risks (NTR) need to be carefully managed to keep the license to operate.
- Select a 100% electric rigless plug and abandonment (P&A) unit to reduce emissions, smell, and noise contour.
- Manage and execute a complex P&A scope of work of 60+ wells in three years.

This paper studies the solutions selected and implemented by the project management team in collaboration with the well operator for a successful start-up and cost-effective well abandonment project.

- Implement the first fully integrated well abandonment project solution for onshore P&A in the Netherlands including well P&A services, hydraulic workover (HWO), logistics, and site preparation.
- Ensure full compliance with the stringent local mining and environmental regulations.
- Select a bespoke P&A unit to provide a robust solution for complex P&A work.
- Select downhole services and technologies to successfully execute a complex, rigless P&A work scope.

The project encompasses over 60 wells on 23 different onshore locations drilled over a 50 year period. The known scope of work and requirements of multiple contingencies while managing NTRs resulted in the selection of a rigless well abandonment solution.

- A modular, highly capable rigless well abandonment unit in combination with enabling downhole technologies provides a total solution for simple and complex wells.
- A 100-percent electrically powered P&A unit reduces emissions, smell, and noise contour. This was thefirst electrified P&A unit in the history of the operator running on grid power. All well site equipment is electrically powered (HWO P&A Unit, Mud/Cement Pumps, and ancillary equipment) to reduce emissions, smell, and noise contour.
- Project management and engineering is key to ensuring efficient planning and close collaboration with the well operator's project team.

- Collaboration between partners enables multi-skilling and reduction of POB to save additional costs.
- Improve efficiencies and execution through extensive after-action reviews and learning curves.
- Successfully execute complex P&A work and re-establish annular cement integrity on multiple complex wells (perforate, wash and cement, section milling, perf, circulate and cement)
- More than 40 wells completed in two years, and operations continue today.
- This is the first fully integrated well abandonment approach that includes full project management, well-site supervision, cross-product services, and extensive third-party management (HWO, logistics, and other third-party service companies).
- A 100% electric P&A unit reduces emissions, smell, and noise contour, delivering a net reduction of CO2 through electrification.

## Project objectives

One of the major operators in the Netherlands has an obligation to plug and abandon hundreds of onshore oil and gas wells. While P&A costs are a big challenge for most operators, other challenges can bring greater costs if they are not appropriately manged. The operator's main objective is to deliver a first-class P&A solution with a specific focus on the following drivers:

- Lower total cost
- No remaining liabilities
- Abandon 20 wells per year
- Comply with SodM (regulator) regulations and stringent standards
- Reduce cost burden for taxpayers
- Reduce CO2 Emissions
- Be a good neighbor—minimize impact of P&A activities

The project discussed here compromises the plug and abandonment of more than 60 onshore wells situated in 23 different locations across the Netherlands. To respond to the operators' P&A campaign objectives, Baker Hughes (the Integrated Well Abandonment Provider) has set up an alliance with an HWO company and a logistics company. Thanks to a collaborative relationship between our partners and the operator, a successful fit-for-purpose solution for the project has been put together.

This solution optimizes all aspects of the plug and abandonment execution and project deliverables, including logistics, site preparation and civil work, well engineering, and onsite well operations.

The key to success has been to engage with the operator in detail from the project's inception. This has allowed the Integrated Well Abandonment Provider to gain a full understanding of the operator's challenges and objectives. Due to the complexity of the project, innovative out-of-the-box thinking has been required to deliver the most optimal solution. Based on the project's requirements and goals, both the operator and the Integrated Well Abandonment Provider agreed that project deliverables would be most effectively delivered by taking a fully integrated approach. The operator selected the Integrated Well Abandonment Provider as the Project Management Lead company. In that role the Integrated Well Abandonment Provider is required to manage and coordinate with partners and the operator so that all the project steps are timely executed, whilst ensuring that all goals are met within the agreed upon scope, time, quality, and budget.

The integrated P&A alliance is composed of:

- **Integrated Well Abandonment Provider:** project management, engineering and well services including cementing, fluids, wellbore interventions and remediation, wireline services, and perforating
- **HWO Partner:** provision of the P&A unit

– **Logistics Partner:** logistic services including rig moves, civil work, and support services

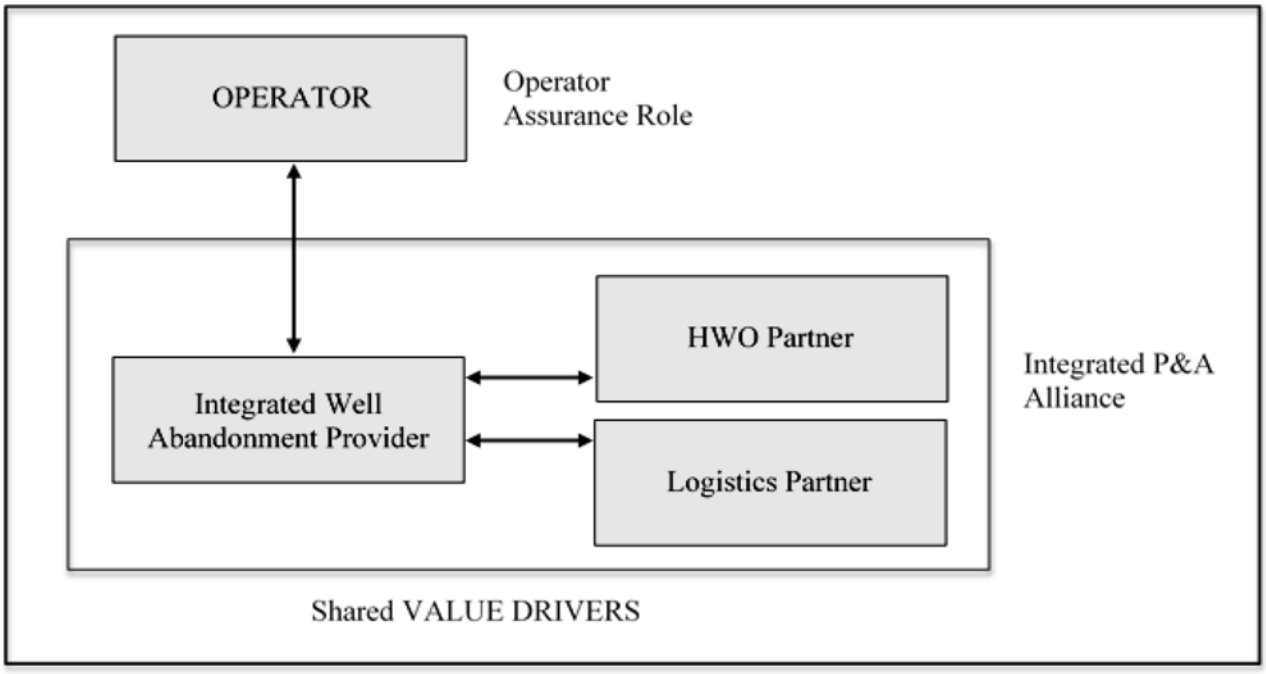



**Figure 1—Integrated P&A Alliance**

## Why a fully integrated approach?

The fully integrated approach allows all parties involved to collaborate, own, and share the project value drivers, thus inspiring a common goal with the operator and alliance partners. By sharing the project successes and challenges, all partners involved in the alliance are motivated and incentivized to work collectively to deliver the best solutions and performance for the project:

– Reduce HSE risks
– Reduce costs
– Avoid duplications
– Understand the project learning curve

## Project organization and responsibilities

– Prework operations: scope required prior to the arrival of the P&A unit completed by the operator
– Project management: the Integrated Well Abandonment Provider
– P&A planning and engineering: operator and P&A Alliance
– Well execution: P&A Alliance
– Well monitoring: operator
– Environmental plug and site decommissioning: operator

## Design of bespoke P&A unit provides a robust solution for complex P&A work

Most of the wells to be abandoned in the project are more than 50 years old. Due to the aging wells and well integrity issues, sustained casing pressure and complex P&A scopes are regularly encountered. As a result, the placement of a permanent barrier across the well often requires the removal of the tubing, casing,

and/or annular integrity remediation in this project. Perforate, circulate and cement (PCC), perforate, wash and cement (PWC) and section milling of different casing sizes and grades are common methodologies used for this project. H2S, LSA, and benzene handling are additional challenges expected on most of the project wells.

To comply with regulations in the Netherlands, the project needs to operate under strict environmental parameters, including noise limitations and emission reduction due to well proximity to housing and nature preserves. Rig moves need to be conducted in an efficient and swift manner to minimize road traffic disturbance since well locations are mainly in urban areas. To meet these challenges, the Integrated Well Abandonment Provider, HWO partner and logistics partner collaborated closely with the operator to design a new bespoke hydraulic workover unit (HWU) capable of handling both simple and complex well P&A work efficiently while complying with all noise and emission regulations. The collaboration benefited from the expertise and experience of each of the alliance companies in executing similar projects in the region, as well as familiarity with the operator requirements and country regulations.

The P&A unit (modular concept) was designed and manufactured to the latest standards and complies with all necessary regulations. The modular concept and small footprint ensure a quick, safe, and efficient rig move. From rig-down to rig-up of the P&A spread, it typically takes 24 hours when moving from well to well on the same location, and 48 hours when moving from site to site. The unit includes a high-performance hydraulic rotary table to deliver rotary capability when used for milling or cutting operations.

The small footprint allows the unit to operate in locations where space is limited.



**Figure 2—P&A spread**

The P&A spread is fully electrified, the rigless unit utilizes an electric-hydraulic power pack, and where possible, runs off the local power grid—thereby offering the ability to be operated via grid renewable energy.

The fluid-circulation package is operated via all-electric pumps, which reduces emissions and noise levels. Through these design innovations, the P&A spread has a very low environmental impact to make operating near housing and nature preserves possible without the requirement of a sound wall on location. Despite working in close proximity to housing, no complaints have been raised about noise or emissions by the public. The fully electrical, rigless unit has a proven track record of being able to perform complex P&A scopes that are usually considered only achievable via the use of a full rig system.

## Project manager—a single point of contact

The project manager leads the alliance team and is also the single point of contact for the operator's project team. The alliance project management team includes assigned focal points from both project alliance partners (the logistics and HWO partner) and well P&A Engineering resources. The project team quickly learned how to collaborate effectively to rapidly drive common goals.

Allowing close collaboration with the operators' project resources, the project management and engineering team were initially located "in house" at the operator premises. However, two weeks after well abandonment operations started, the COVID-19 pandemic resulted in a lock-down whereby the "in-house" collaboration was changed to a "work-from-home" solution in early 2020. Close collaboration between all parties continued, and all subsequent wells have been successfully planned and executed. 24/7/365 operations have continued throughout the pandemic with COVID-19 measurements and risk mitigation strictly adhered to at the well site.

The chart below provides an overview of the project alliance team organization

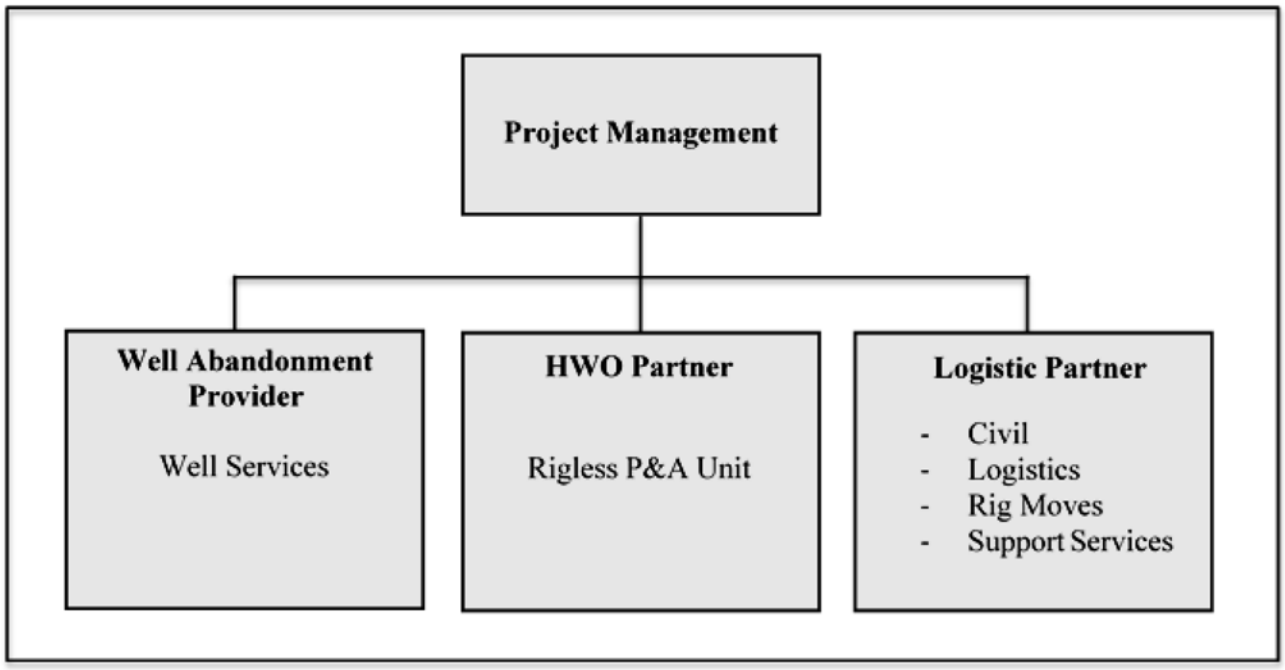



**Figure 3—Integrated Alliance**

## Single invoice

At the end of each well, a single invoice is generated which includes all alliance services and other third-party services where applicable.

## Engineering

The operator is responsible for developing an initial P&A basis of design. Upon receiving this, the alliance then works closely with the operator to develop the detailed well engineering for each well. Early engagement with the alliance is critical in ensuring that the most robust technical and cost-effective abandonment solution is selected to address each well's unique challenges. The detailed planning is worked jointly between the operator's engineers and the alliance engineers (the Integrated Well Abandonment Provider and HWO Partner) to select the most efficient solution, while fully complying with the stringent SodM requirements and other country regulations. This includes:

- Review the P&A basis of design and selection of the P&A solution
- Well operational sequences for efficient execution and time saving
- Selection of surface and downhole tools and development of operational procedures for each well
- After-action review
- Apply lessons learned

## Project start up

The project's detailed planning and engineering started seven months before the start of operations. During this period, project procedures and equipment-spread acceptance processes were established and completed. The well-site operations started in February 2020.

## Multiskilling and reduced POB

The P&A spread including a rigless P&A unit, fluids, and cementing only requires seven personnel per shift to operate (five HWO operators plus two multi-skilled operators), lowering the costs of the well abandonment solution compared to an equivalent rig-based operation. These multi-skilled operators help with the rigless P&A unit operations and are also the main operators for pumping and cementing operations.

## First batch

- The first batch was expected to be the most challenging due to both the complexity of the wells and the new project team (new contract, new partners, new P&A unit, new applications).
- The first batch included different well types (simple and complex) that required different P&A solutions, procedures, and equipment for each well. Also being the first batch of the campaign, it required planning for several contingencies (both procedures and equipment). The table below (Table 1) provides an overview of the first batch executed scope, and level of complexity.

**Table 1—First batch executed scope and level of complexity**

| | H2S location | LSA | Benzene Suspected | PWC | PCC | SM | N° BP set | N° Cement plugs pumped | Total Tubular Retrieved (10 wells) (m) |
|---|---|---|---|---|---|---|---|---|---|
| Well 1 | H2S | | | | | | 2 | 2 | |
| Well 2 | H2S | | | | | | | 1 | |
| Well 3 | H2S | | Benz | | | | | 1 | |
| Well 4 | H2S | LSA | Benz | | PCC | | 2 | 3 | |
| Well 5 | H2S | | Benz | PWC | PCC | | 1 | 3 | |
| Well 6 | H2S | LSA | Benz | PWC | | | 1 | 3 | |
| Well 7 | | | Benz | PWC | PCC | | 1 | 2 | |
| Well 8 | | LSA | Benz | | | SM | | 1 | |
| Well 9 | H2S | LSA | Benz | | PCC | | 2 | 3 | |
| Well 10 | H2S | | Benz | | | SM | 2 | 3 | |
| **Total** | **8** | **4** | **8** | **3** | **4** | **2** | **11** | **22** | **34 561** |

The execution of the first 10 wells showed valuable data to be gathered and analyzed. Lessons learned were implemented in refining and optimizing solutions for the forthcoming wells. Given the different design,

age, and integrity issues of the wells to be abandoned, different solutions and approaches are required for each well. Although some wells may have had similarities, every well needed to be planned individually. The complex wells require casing cement remediations by section milling (SM), perf wash and cement (PWC), or perf circulate and cement (PCC). The remediation solution depends on several factors, the main ones being the well condition, the annulus cement integrity, and the time and cost impact of the solution for each well. The solutions are planned thoroughly and optimized to save time and costs, never compromising safety and compliance with regulations.

Several optimizations were introduced to save time and costs. For example:

- Use the tubing to set the reservoir plugs and eliminate additional tripping times, saving an average of one day per well
- Combine scraper run and BP setting in one run

As shown in Table 1, the well status, the variety of casings types, and different remediation solutions all result in a requirement for a large portfolio of tools and products to respond to the equipment requirements and all P&A solutions or contingencies. It also requires an optimized logistics plan to minimize tools and fluids on location, eliminate unnecessary costs, and reduce footprint, especially in locations where space is limited.

## Project achievement and well delivery to date

Table 2 provides a project overview with a total of 36 wells (4 batches) delivered over a period of 22 months.

**Table 2—Project Execution Summary (to date)**

| | First Batch | Second Batch | Standalone wells | Third Batch | Fourth Batch (ongoing) | Total |
|---|---|---|---|---|---|---|
| N° wells | 10 | 10 | 4 | 7 | 5 | 36 |
| GRID/Generator | 3 wells GRID | 10 wells GRID | | 5 wells GRID | 5 wells GRID | 23 |
| H2S location | 8 | 0 | 1 | 6 | 0 | 15 |
| LSA location | 4 | 0 | 2 | 3 | 0 | 9 |
| Benzene Suspected | 7 | 9 | 1 | 5 | 5 | 27 |
| PWC | 3 | 1 | 1 | 0 | 0 | 5 |
| PCC | 4 | 0 | 0 | 0 | 0 | 4 |
| SM | 2 | 1 | 2 | 3 | 1 | 9 |
| N° BP set | 11 | 3 | 3 | 7 | 2 | 26 |
| N° cement plugs | 22 | 24 | 4 | 12 | 4 | 66 |
| **Total Tubular retrieved (36 wells) (m)** | | | | | | 94 309 |

Of the 36 wells, 18 wells were complex and required annulus cement remediation.

- 5 × PWC in 7-in., 7⅝-in., 10 ¾-in., and dual casing 7-in. × 9⅝-in.
- 4 × PCC in 13 ⅜-in. casings
- 9 × SM in 7-in., 7⅝-in., 9⅝-in. and 13⅜-in.

Cut- and pull-casing operations were conducted on all 36 wells. Approximately 13,000 meters of casing were retrieved and disposed of (including 7-in., 7⅝-in., 9⅝-in., 10¾-in., and 13⅜-in. casings). More than 81,000 meters of tubing was retrieved and disposed of. Twenty-six bridge plugs were set, and 66 cement

plugs were pumped. Most of the wells are classified as H2S wells and have LSA and benzene, which required additional management plans and HSE procedures.

The graphs below (Figure 4) show the overall performance of first and second batches (planned versus actual time of the first 20 wells). As the project progressed with more data and lessons learned, the unknowns were identified to allow for better planning and fewer challenges. This paved a path for better contingency planning and helped the alliance execute the well abandonments faster than planned. The second batch was delivered 44 days ahead of schedule.

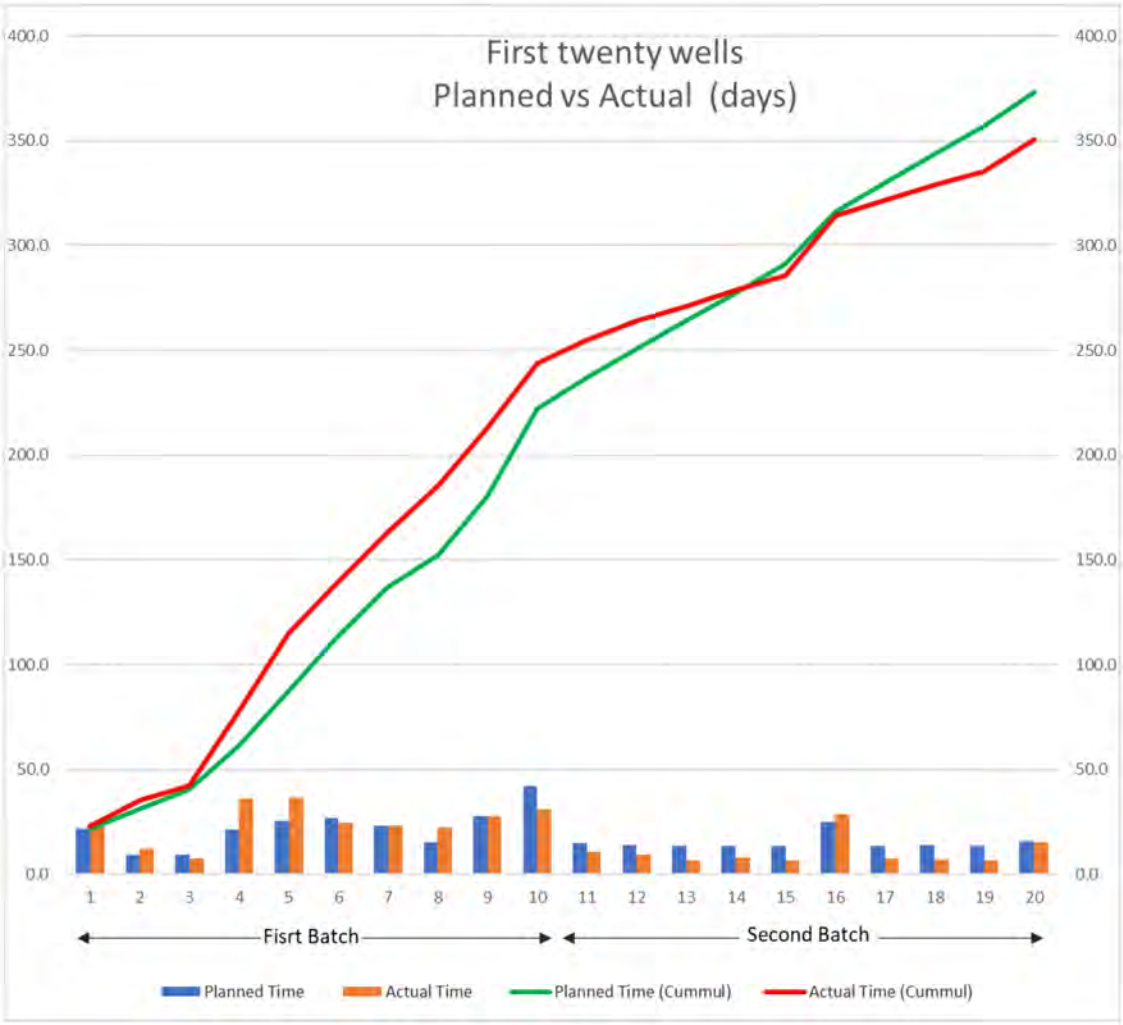



**Figure 4—First twenty wells - Planned vs Actual (days)**

## Reduction of noise level and emissions

The use of a rigless unit, which can function 100% electrically, contributed to significant reduction in noise levels and CO2 emissions. This was one of the main objectives to comply with the country's regulations.



**Figure 5—This is the first fully integrated well abandonment approach with a 100% electric P&A unit that significantly reduced CO2 emissions, smell, and noise contour.**

## Operation optimization and new technologies

The alliance, in collaboration with the operator, has continuously pushed the boundaries to reduce costs and environmental impact. The introduction of no swarf to surface-section milling technology already was mobilized as a contingency and is planned for upcoming wells. As highlighted in Table 1 and 2 above, there are a significant number of wells that required annular cement remediation by section milling. The milling of 9⅝-in. and 7-in. casings, using a no-swarf to surface system, will eliminate the handling and disposal of many tons of swarf. This will further reduce environmental impact, HSE risks, personnel exposure, project costs, and time.

## Results and conclusion

The Integrated Well Abandonment Provider, HWO partner, and logistics partner have successfully introduced the first fully integrated well abandonment approach utilizing a 100% electric P&A unit. The fully integrated approach proved to be the right solution for such a complex and challenging project. It allowed all parties involved to collaborate, own, and share the project value drivers to deliver the best solutions and performance for the project, ultimately reducing project costs without compromising safety. Data and lessons learned are continuously gathered and applied to continuously improve project performance. The use of the 100% electric P&A unit has significantly reduced CO2 emissions, smell, and noise pollution to incur zero NTR and ensure a good corporate relationship with the public. To date, the alliance has successfully completed 36 wells (18 simple and 18 complex) over a 22-month period, all within the allotted time and budget.

## Abbreviations

| | |
|---|---|
| CO2 | Carbon Dioxide |
| H2S | Hydrogen Sulfide |
| HWO | Hydraulic Workover |
| HWU | Hydraulic Workover Unit |
| LSA | Low Specific Activity |
| NTR | Non-Technical Risk |
| SodM | Staatstoezicht op de Mijnen |