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Uncertainty and Risk Management in E&P: A Practical Approach

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Abstract

This article presents a practical approach to uncertainty and risk management in oil and gas production, drawing on LUKOIL's project experience. It describes, in detail, the step-by-step procedures used to identify, assess, and manage uncertainties and risks through Uncertainty Management Plans and Risk Management Plans (hereinafter referred to as UMPs/RMPs). In this context, UMPs/RMPs are not merely formal documents, but a working culture and discipline embedded in the day-to-day activities of project teams. Their application makes it possible to avoid catastrophic errors through explicit consideration of pessimistic scenarios, maximize asset value by selecting more realistic and flexible solutions, facilitate effective discussion of uncertainties and risks between technical specialists and project or asset managers, and shift the focus from searching for a single correct answer to managing a portfolio of opportunities. The use of UMPs/RMPs enables project teams to move from the illusion of full control to a more realistic and effective mode of operation. By adopting this systematic approach, oil and gas companies are able to make balanced decisions in one of the world's most uncertain industries.

Keywords: oil and gas project management, capital project, subsurface uncertaintyies, project decisions, decision-making process

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油气开采中不确定性与风险管理的实践经验

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摘要

本文介绍了卢克石油公司某油气开采项目中不确定性与风险管理的实践经验。文章详细阐述了根据经批准的内部规范性文件 —《地质与开发领域不确定性与风险管理规划方法》（PUN/PUR）— 在处理不确定性与风险时所采用的一系列程序。该方法不仅仅是一份文件，更是一种已融入项目团队日常工作的管理文化与工作纪律。其在项目中的应用能够：通过明确考虑悲观情景来避免灾难性错误；通过选择更为现实且更具灵活性的方案来实现资产价值最大化；促进技术专家与项目或资产管理者之间就不确定性与风险开展有效讨论；将关注重点从寻找唯一正确答案转向对机会组合的管理。PUN 方法论的应用使项目团队能够从"完全控制"的幻觉转向更加现实且有效的工作方式。借助 PUN 方法论及系统性方法，油气公司得以在全球最具不确定性的行业之一中作出审慎决策。

关键词： 油气项目管理，资本项目，地质不确定性，项目决策，决策过程

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Introduction

The process of planning uncertainty and risk management in geology and field development (hereinafter referred to as UMPs/RMPs) is a core component of decision-making within an integrated project management system and applies to all aspects of field development management [Voevodkin et al., 2019; Mamedov, Mardanov, 2025]. Project leaders and managers should have several decision-making tools at their disposal; otherwise, project management in many cases becomes overly dependent on chance.

Through regular UMP workshops and related work processes conducted for projects and assets, project teams develop a fundamental understanding of the degree of uncertainty and risk present at each phase of project implementation. The outcomes of uncertainty and risk management are then incorporated into the broader reservoir management process as documented expectations.

The uncertainty management planning process should be used proactively to identify and address uncertainties throughout the entire life cycle of a project or asset. Similarly, the risk management planning process should be applied to identify and mitigate risks through appropriate mitigation measures and contingency actions.

Well-developed uncertainty and risk management plans enable project teams to increase the value of information needed for a reliable assessment of reservoir productive potential. UMP and RMP documents should be integrated into the project or asset development work plan and regularly updated and reviewed. To ensure consistency, they should also be aligned with other field development management documents.

It is essential that the cross-functional team involved in UMP and RMP workshops and in preparing the relevant documents include drilling and completion specialists, facilities engineers, operations personnel, geologists, reservoir engineers, and commercial specialists. To remain relevant, UMP and RMP documents should be updated annually or whenever significant new information becomes available [Voevodkin et al., 2019; Mamedov, Mardanov, 2025].

1. Conceptual Framework for Uncertainty and Risk Management

Today, most oil and gas companies use structured, sequential procedures for uncertainty and risk analysis when evaluating exploration and production projects. These procedures involve identifying, classifying, and incorporating uncertainties and risks into project work plans (Figure 1).

Uncertainty and risk management makes it possible to:

- make informed decisions in complex situations characterized by multiple objectives and a high degree of uncertainty;
- address difficult trade-offs and stakeholder preferences in exploration and production decision-making;
- take all relevant factors into account in a comprehensive and systematic manner when making exploration and production decisions.

Within LUKOIL's project management system for major capital projects, five project phases are distinguished (Figure 1). To support uncertainty and risk management planning, UMP workshops are held during four phases of project implementation, from Phase 1, Definition, through Phase 3, Execution. This approach improves both decision-making quality and the overall effectiveness of project development. During Phases 1 and 2, UMP workshops focus on reservoir characteristics and on developing a plan to resolve or reduce uncertainties; during Phases 3 through 5, the focus shifts to preparing a risk management plan.

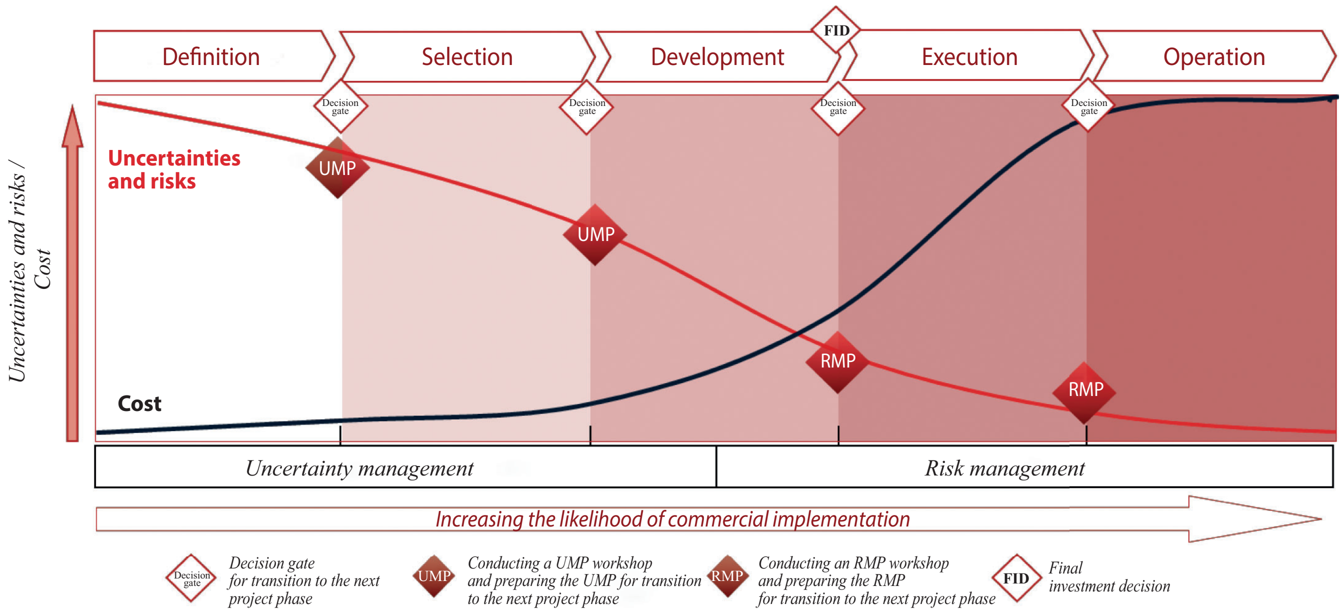
UMP workshops focused on uncertainties may be held at the end of Phase 1 or the beginning of Phase 2, in the middle of Phase 2, and at the end of Phase 2 or the beginning of Phase 3.

During Phases 1 through 3, uncertainties are identified, categorized, and incorporated into work plans, and the value of information is assessed in order to prepare a strategic uncertainty management plan, that is, the UMP document. The results of the UMP workshop are used to define the scope of work for subsequent phases and should be reflected in the project budget.

RMP workshops focused on risks are held in the middle of Phase 3, at the end of Phase 3 or the beginning of Phase 4, at the end of Phase 4 or the beginning of Phase 5, and at the end of Phase 5.

It is assumed that uncertainties decrease from phase to phase and should be reduced to a minimum, though not eliminated entirely, by Phase 4, Execution. This helps improve the quality of decisions aimed at reducing or, where possible, eliminating existing uncertainties. At the same time, it is important to understand that the main purpose of a UMP workshop is not to eliminate uncertainty altogether, but to support sound decision-making under conditions of uncertainty.

Although UMPs focus primarily on the subsurface aspects of a project, it is also important to assess uncertainties in other disciplines that may affect field development. Therefore, before conducting a UMP workshop, it is necessary to ensure that all required specialists and decision-makers are available to participate. These usually include reservoir engineers, geologists, petrophysicists,



Source: compiled by the authors.

Fig. 1. Uncertainty and Risk Management Process Across the Life Cycle of Major Capital Projects

drilling and completion specialists, capital construction and technical operations personnel, production specialists, health, safety, and environmental specialists, economists, risk specialists, and others.

UMP workshops provide project teams with clear procedures for identifying, assessing, and developing plans to reduce or resolve key geological and field development uncertainties. The UMP document produced as a result of the workshop is linked to and aligned with research and pilot fieldwork plans, technical plans, appraisal and exploration programs, field development and redevelopment projects, technical and authorial supervision activities, and project investment passports.

2. Preparing for a UMP Workshop

As noted above, before conducting a UMP workshop, it is important to ensure that all required specialists are available to participate. It is also necessary to agree in advance on which disciplines and participants should be involved in the workshop and whether project partners should be invited.

The sources of uncertainty in a project or asset include information related to geology, field development, drilling and well completion, facilities, and other areas (Figure 2).

Before the workshop, the venue should be selected, the meeting room reserved, and all audio and video requirements confirmed. It should also be verified whether electronic spreadsheets can be projected on a large screen with all columns visible at once, and whether the room is adequately equipped with desks, chairs, extension cords, network connections, and other practical necessities in accordance with a pre-prepared checklist. These arrangements are important for ensuring an efficient workflow for all workshop participants.

Before organizing the next UMP workshop, the following points should be clarified:

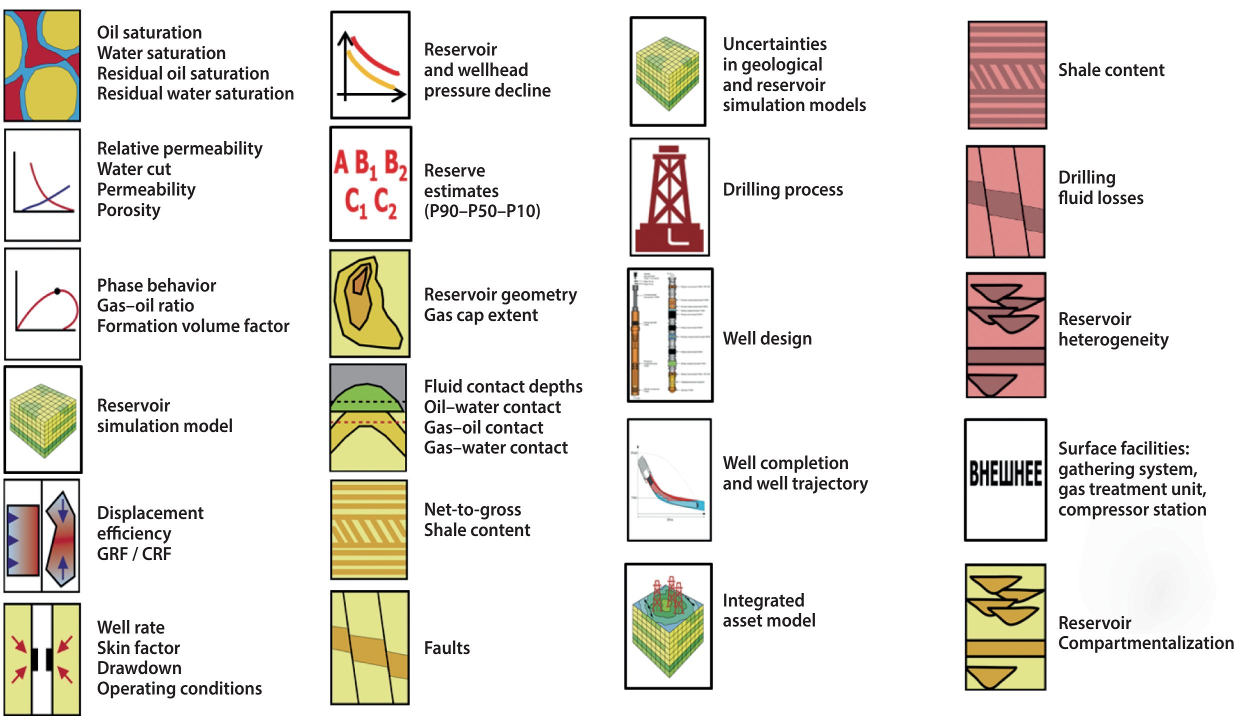
- whether a previous UMP exists for the project or asset under consideration, and when it was last updated;
- whether implementation of the actions defined in the previous uncertainty management plan has been reviewed;
- whether the project or asset work plan is aligned with the previous UMP document;
- whether the results of the UMP workshop will affect activities planned for the project or asset during the year;
- whether the objectives and expected outcomes of the upcoming UMP workshop have been agreed with stakeholders;
- whether agreement has been reached on which disciplines and specialists should participate in the workshop and whether project partners are to be invited.

3. Conducting UMP Workshops

UMP workshops are conducted using structured facilitation techniques similar to those applied in uncertainty management sessions in geology and field development, as well as idea-generation and discussion methods tailored to the specific purpose and objectives of the workshop. Workshop activities are supported by working spreadsheets. The workshop is carried out by a working group composed of specialists in geology and reservoir engineering, drilling and well completion, facilities design and operations, production, health, safety, and environment, economics, and other relevant disciplines. During the workshop, the group performs the following main tasks:

1) identifies, categorizes, and prioritizes uncertainties in geology, field development, drilling and well completion, surface facilities, and related areas using VUDOR categories;
2) describes uncertainty ranges, including measures, units, sources of information, and degree of uncertainty;
3) assesses the impact of each uncertainty on key project decisions using the Low, Middle, and High ranking scale and constructs a 3×3 matrix showing degree of uncertainty versus degree of impact on technical and economic indicators;
4) identifies the key decisions in the project decision hierarchy that should be included in the uncertainty management plan;
5) identifies key uncertainties and assesses their impact on key decisions, followed by construction of a 3×3 matrix of degree of uncertainty versus degree of impact on key project decisions;
6) assesses the degree to which key uncertainties can be resolved and develops possible response options, followed by construction of a 3×3 matrix of degree of resolvability versus degree of impact on key project decisions:
7) prepares a detailed strategic uncertainty management plan;
8) prepares a high-level plan for uncertainty reduction.

At the beginning of the UMP workshop, presentations are delivered in sequence by the project or asset leader or manager on the current status of the project or asset, including its objectives, scope, development concepts, and project boundaries. Geology specialists present information on the range of reservoir properties, including available 3D digital models and structural maps of productive formations, 3D seismic data, core and fluid sampling results, and related information. Reservoir engineers present the project decisions already adopted or the results of pilot development if field operations are already underway. Drilling and completion specialists describe key uncertainties and risks associated with well construction. Production specialists report on uncertainties and risks related to surface facilities, including the gathering, treatment, and transportation systems for hydrocarbons. Economists, risk specialists, and HSE specialists may also make presentations if their participation has been agreed in advance.



Source: compiled by the authors.

Fig. 2. Root Causes of Uncertainty

The results of the joint discussion of specialist presentations are entered into the VUDOR Register under the following categories:

- static uncertainties: uncertainties associated with objective natural properties, such as the exact volume of oil reserves in the reservoir or the physical properties of the rock. These factors must be measured, assessed, and incorporated into models, but they cannot be altered;
- dynamic uncertainties: uncertainties affecting recoverable reserves. Their relative importance depends on the reservoir development system. They may also be related to equipment performance, for example the causes of pump failure or measurement errors. These uncertainties can and should be reduced through the use of more reliable equipment, regular maintenance, and system redundancy;
- well-related uncertainties: a distinct category directly associated with drilling and well operation, such as wellbore instability or drilling complications. This highly specialized category helps engineers focus on specific risks;

Table
VUDOR Register

Category	Code	Term	Description
Issue Type	V	Value Driver	A factor that indicates the project's efficiency or value relative to other projects
	U	Uncertainty	A factor that matters, but whose value is uncertain and should therefore be described as a range of possible values.
	D	Decision	A choice that must be made.
	O	Other	Issues that do not fall within any of the other issue types
	R	Risk	A consequence of geological and field development uncertainties that may jeopardize the achievement of project objectives. Risk may be either technical or commercial
Decision Type	G	Given	Decisions that have already been made
	F	Focus	The most important decisions at the current project phase.
	T	Tactical	Decisions that may be important but are not required at the current phase of project execution
Uncertainty Category	S	Static	Uncertainties affecting hydrocarbons initially in place
	D	Dynamic	Uncertainties affecting recoverable reserves. Their relative importance depends on the reservoir development system.
	W	Well-related	Uncertainties affecting drilling, well completion, well productivity, and well integrity
	O	Operational	Uncertainties affecting facility performance and other factors, including product storage, offloading, and transportation
	P	Political	Uncertainties associated with changes in legislation, government regulation, and public response to the company's actions. They may arise from political instability, shifts in public governance, or sharp swings in public opinion
	C	Commercial	Uncertainties associated with market demand for the produced product and with price changes. They determine whether the project will be able to achieve its target revenue and profit indicators under changing market conditions.
Controllability	U	Uncontrollable	Uncertainties whose outcomes cannot be controlled. For example, the range of uncertainty associated with average effective porosity can be narrowed, but its actual value cannot be changed
	C	Controllable	Uncertainties that can be influenced through direct action. For example, the use of modern well completion methods may improve the resulting skin factor, although some uncertainty in execution still remains. In practice, some controllable uncertainties are effectively decisions.
Simple/Complex	S	Simple	Uncertainties driven by a single factor, such as horizontal permeability
	C	Complex	Uncertainties that are influenced by several simpler uncertainties; for example, oil reserves depend on porosity, area, reservoir thickness, water saturation, and other parameters
Risk Type	SSI	Subsurface Integrity	Defined for process safety purposes, for example equipment depressurization or loss of containment
	NORM	Conventional Risk	Risk not related to production process safety

Source: compiled by the authors.

- operational uncertainties: uncertainties arising from the company's internal processes, such as logistics disruptions, human factors, or planning errors. These are managed through business process optimization, personnel training, and the development of standards;
- market and commercial uncertainties: fluctuations in prices, demand, exchange rates, and competitor actions. These are typically managed through hedging, diversification, flexible pricing, and market analysis;
- political and country-level uncertainties: changes in legislation, sanctions, political upheaval, and tax policy. These are managed through political analysis, lobbying, geographic diversification of assets, and political risk insurance.

Classifying uncertainties by category gives the working group a clear understanding of how responsibilities are allocated. For example, technical uncertainties and risks are addressed by engineers, commercial uncertainties by marketing and finance specialists, and political uncertainties by legal and strategy teams.

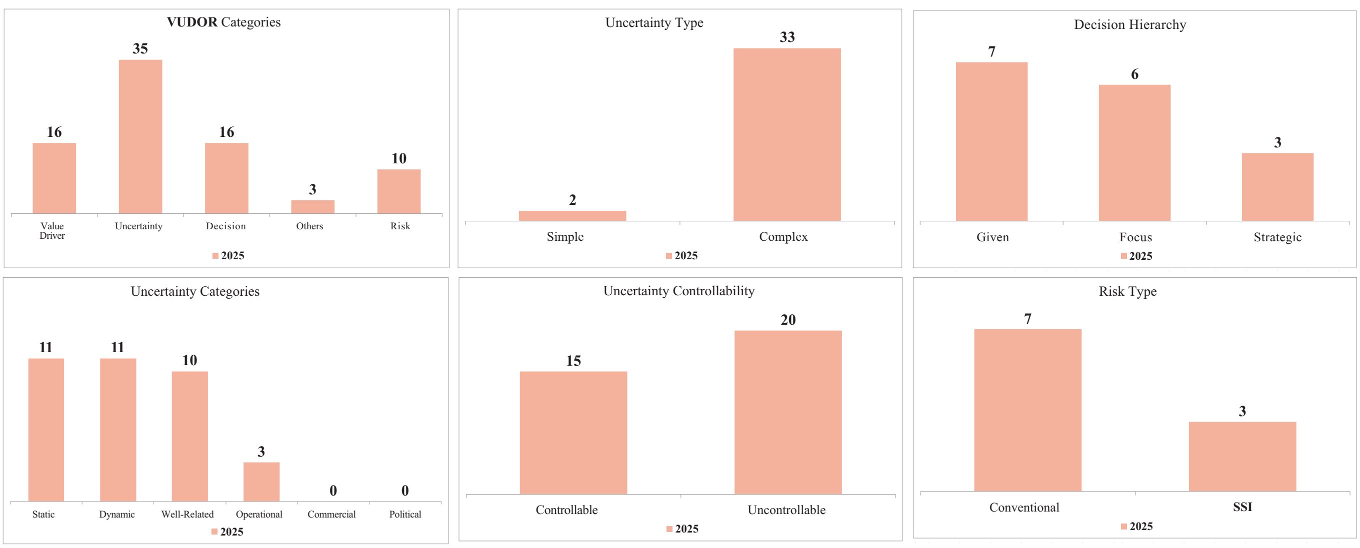
Classifying uncertainties by degree of complexity helps the team choose an appropriate analytical and decision-making approach and avoid strategic mistakes:

- simple uncertainties (where underlying patterns are clear): cause-and-effect relationships are evident, and past experience provides a reliable basis for anticipating future outcomes; for example, the known probability of failure of a particular type of valve. Such uncertainties can be addressed through statistical analysis, standard procedures, and established best practices;
- complex uncertainties (in a highly dynamic environment): cause-and-effect relationships are unclear, the system is constantly changing, and past experience is not always a reliable guide; for example, the market response to the launch of a fundamentally new product. Recognizing that the team is dealing with complex uncertainty calls for a different set of tools, such as experimentation, adaptive strategies, scenario planning, and pilot projects. The objective is not to predict every outcome in advance, but to build a system capable of responding quickly to change.

Classifying uncertainties by degree of controllability helps the team allocate time, money, and effort more effectively:

- controllable uncertainties: uncertainties that can be influenced through direct action, such as product quality, employee competence, or supply chain reliability. These should receive the greatest share of effort and resources, including the development of specific action plans to reduce or manage them;
- uncontrollable uncertainties: factors that cannot be directly influenced, such as global oil prices, weather conditions, a global economic crisis, or government decisions. The key task in such cases is not to try to change them, which is futile, but to adapt to them. This can be done through ongoing monitoring, contingency planning, the creation of financial buffers, and diversification to reduce dependence on any single uncontrollable factor.

The purpose of this classification is to describe all identified uncertainties as precisely as possible. For example, during a UMP workshop for one of LUKOIL's



Source: compiled by the authors.

Fig. 3. VUDOR Histogram

projects, the working group identified 35 uncertainties, of which 11 fell into the static category, 11 into the dynamic category, 10 into the well-related category, and 3 into the operational category. At the same time, 33 out of 35 uncertainties were recognized as complex, and 20 out of 35 as uncontrollable (Figure 3).

Project value drivers may include the following:

- the uniqueness of the field in terms of hydrocarbon reserves;
- high crude quality and favorable oil prices;
- large remaining oil reserves;
- low production costs;
- high production volumes;
- ongoing efforts to improve operating efficiency;
- deployment of advanced technologies, particularly in future expansion phases;
- experience in drilling deep wells;
- a high level of automation and control;
- full control over the value chain, with the operating company owning and managing the entire infrastructure;
- access to export routes;
- a diversified buyer base;
- high profitability;
- the project's significance for the country or republic in which it is located;
- reputational value for partners;
- concession expiry in 2030.

An understanding of a project's value drivers supports managerial decision-making. These drivers help managers prepare more accurate budgets and forecasts and make decisions more quickly and effectively. They also help shape business development strategy and make the company more flexible and better able to adapt to changing conditions.

Once the VUDOR Register has been completed, the working group jointly develops the project decision hierarchy. This hierarchy is a tool for structuring and prioritizing project decisions. It helps the team focus on the most important decisions while taking previously adopted decisions and assumptions into account (Figure 4). The hierarchy is developed collectively by the full working group, including representatives of both the project team and the asset.

The jointly developed and agreed decision hierarchy divides all project decisions into three categories:

1. Given decisions are decisions that have already been made and are not subject to change. Examples include:

- field development plan parameters;
- the inverted waterflooding system;
- the production rate through 20XX;
- water supply from Formation A;
- the water-cut profile;
- the pad startup sequence;
- drilling scheduled for 2028–2034;
- the artificial lift strategy for the well stock.

2. Strategic (focus or key) decisions are the most important decisions to be made at the current project phase. These may include:

- water injection and water treatment volumes;
- the effectiveness of acidizing, water shutoff operations, and remedial cementing;
- sustaining planned production levels;
- pilot EOR projects at the evaluation stage;
- infill drilling in Phase 1;

3. Tactical decisions may also be important, but they can only be made at subsequent project phases or milestones. These may include:

- infill drilling in Phase 2;
- extension of the production plateau;
- pilot EOR projects at the implementation stage.

Source: compiled by the authors.

Fig. 4. Hierarchy of Project and Asset Decisions

Based on the results of the active discussion and brainstorming, the key project decisions are identified.

Classifying all issues and topics raised during the workshop according to the VUDOR categories helps the project team move from a fragmented response to individual project problems toward a more systematic management approach. This provides several important benefits:

- prioritization: a clear understanding of what needs to be addressed first;
- more efficient resource allocation: time and money are directed toward controllable uncertainties and risks, as well as adaptation to uncontrollable ones, rather than being wasted on ad hoc responses to isolated problems;
- better decision-making with less stress: when uncertainty is structured, it is less likely to trigger re-

active or emotionally driven responses. Decisions are then based on analysis rather than intuition or fear;

- improved communication: a shared classification framework helps specialists from different disciplines, including geologists, engineers, and economists, communicate more effectively and develop a common understanding.

During the workshop, the working group, that is, the project team, jointly assesses the impact of uncertainties on the project's technical and economic indicators, which may include oil reserves, approved daily oil production rate, plateau duration, oil production per well, projected water-cut profile, and project NPV. The impact of each uncertainty on project decisions is ranked as Low (L, green, weight 1), Middle (M, yellow, weight 2), or High (H, red, weight 3). The same scale is used to assess the impact of uncertainties on focus decisions. If an uncertainty has no effect on project or focus decisions, it is assigned the rating NA (Not Applicable).

Figure 5 shows the working table used for weighted ranking of the impact of uncertainties on project decisions, which forms the core of the UMP document. This table is created in specialized software and includes the following mandatory columns:

1) Unique uncertainty identification number (ID):

– used to track the category and type of uncertainty (static, dynamic, commercial, political, etc.);

– used to describe the uncertainty in precise terms, for example, uncertainty in net effective oil-saturated thickness (NEST) in the southern part of the field;

2) Assessment and ranking of uncertainties as Low, Middle, or High:

– quality of information: the degree of confidence in the available estimates (High indicates good-quality data, whereas Low indicates limited data);

– impact on the project: a quantitative assessment of how changes in a given parameter affect key indicators such as NPV, production, and CAPEX, using a Low/Middle/High scale;

– priority: determined using a 3×3 matrix based on degree of uncertainty and degree of impact. The highest priority is assigned to uncertainties with a Middle or High degree of uncertainty and a Middle or High degree of impact on project decisions.

ID #	Copy from VUDOR Неопределенности	Degree of uncertainty (H,M,L)	Weighted indicators	Degree of impact (H,M,L,0)	НГЗ	Поддержание полки добычи после 2030 г.	Утвержденный КИН	Накопленная добыча нефти до 2030 г.	CAPEX в период Концессии	Удельная себестоимость добычи нефти	NPV (LF)	Продление периода "плато" добычи на высоком уровне
17	Неоднозначный характер нефтенасыщения по площади и разрезу(объект х)	M	12,02	M	L	M	M	H	NA	NA	L	H
18	Неоднозначный характер нефтенасыщения по площади и разрезу(объект Y)	H	14,03	H	H	NA	H	H	NA	NA	M	H
19	Изменение проницаемости в процессе эксплуатации (причины, законы)	M	11,03	M	NA	M	M	M	NA	NA	M	H
20	Геомеханическая модель	H	12,02	M	NA	M	M	M	M	NA	M	M
21	Изменение продуктивности скважины во времени (PI)	M	15,02	H	NA	H	H	H	NA	L	M	H
22	Содержание CO2, H2S в продукции на объекте Y	L	7,04	M	NA	NA	NA	NA	M	M	M	L
23	Распределение давления по зонам (платформа, борт, склон)	H	8,03	M	NA	M	M	M	NA	NA	L	L
24	Неравномерная выработка запасов нефти по площади и разрезу	H	13,01	M	NA	L	L	L	M	H	H	M
25	Выбытие скважин (в том числе из-за обводнения)	H	14,01	M	NA	H	H	H	L	L	L	M
26	Межремонтный период скважин	L	8,01	L	NA	L	L	L	L	L	L	M
27	Выводы скважины на режим (длительность)	M	7,03	L	NA	M	L	L	NA	L	NA	M
28	Kv/Kh	M	10,01	M	NA	M	M	M	L	L	L	L
29	Зависимость ОФП, концевые точки)	H	7,04	M	NA	M	M	M	NA	NA	NA	L
30	Межколонное давление (быстрый набор давления, около 70 скважин)	L	10,01	M	NA	M	M	M	L	L	L	L
31	Изменение свойств пластовых флюидов резервуара	L	8,01	L	NA	L	M	L	L	L	L	L
32	Изменение обводненности продукции скважины	H	15,01	M	NA	M	M	L	H	H	M	M
33	Распространение зон трещиноватости	H	7,04	M	NA	L	H	L	NA	NA	NA	M
34	Малый объем ПГИ и керна на Объекте Y	H	7,05	H	H	NA	H	L	NA	NA	NA	NA
35	Высокая вариабельность по проницаемости на Объекте Y	H	3,06	M	NA	NA	M	NA	NA	NA	NA	L
36	Неясное распределение доломитизированных зон на Объекте Y	M	5,05	M	M	NA	M	NA	NA	NA	NA	L
37	Продуктивность Объекта Y	M	5,05	M	M	NA	M	NA	NA	NA	NA	L
38	Насыщенности по разрезу (зоны подвижной воды в объекте Y), водонасыщенные линзы	H	3,06	M	NA	NA	M	NA	NA	NA	NA	L
39	Причины высокой обводненности в скв. 2 и 3 (объекты X и Y)	H	1,07	NA	NA	NA	NA	NA	NA	NA	NA	L
40	Разница в пластовых давлениях объектов X и Y	H	3,06	M	NA	NA	M	NA	NA	NA	NA	L
41	Зависимость проницаемости матрицы от кавернозных/трещинных интервалов (объект Y)	M	12,02	H	M	M	H	M	NA	NA	M	L
42	Фациальная изменчивость склоновой зоны: Прогноз сети естественных трещин и их связь с матрицей	M	8,02	L	M	L	M	L	NA	NA	L	L
43	Качество матрицы (при стимуляции ПЗ скважин)	H	6,03	L	NA	L	M	L	NA	NA	L	L
44	Различие в ВНК объектов X и Y	H	10,02	M	H	M	M	L	NA	NA	L	L
45	Неподтверждение ВНК, что критично для бурения горизонтальных скважин	H	14,02	M	M	H	H	L	NA	NA	M	H
46	Завершение программы бурения	H	10,04	M	NA	H	H	L	NA	NA	NA	H
47	Результаты освоения скв. №1 влияющее на продолжение буровых работ и разработку объекта Y	H	6,05	M	NA	M	M	NA	NA	NA	NA	M
48	Эффективность ППД закачкой газа (прорыв газа в доб.скв.)	H	10,01	M	NA	M	M	M	L	L	L	L
49	Эффективность водоотдления	H	6,04	M	NA	NA	NA	NA	M	L	M	L
50	Водопроявление > 10%	H	5,03	L	NA	L	L	NA	NA	L	L	L
51	Эффективность ППД	H	7,02	L	NA	L	L	NA	L	L	L	M

Source: compiled by the authors.

Fig. 5. Assessment of the Degree of Uncertainty and its Impact on Technical Solutions and the High-Level Project Decisions

After the working group has jointly assessed the degree of uncertainty and the degree of impact on project decisions through brainstorming (Figure 5), 3×3 matrices are used to identify key uncertainties. Mapping uncertainties on a 3×3 matrix enables the project team to focus on those with a medium or high impact on project decisions. As an illustrative example, several 3×3 matrices are presented in Figures 6–8.

Using these 3×3 matrices, the working group identified 29 key uncertainties within the project or asset that had a medium or high impact on project decisions. At the final stage of the UMP workshop, the group discusses the further work required to address these key uncertainties. It then prepares a table entitled Strategic Uncertainty Management Plan, which constitutes the UMP document. This document sets out a detailed strategy for addressing key uncertainties. In doing so, project team members jointly determine which uncertainty-reduction measures are likely to provide the greatest benefit and select the preferred course of action. The UMP document includes the title and description of each activity, its cost, labor input, start and finish dates, and the responsible persons. The detailed uncertainty management plan is supplemented by a high-level work plan defining responsibilities, timelines, and the set of activities required to reduce uncertainty.

The Strategic Uncertainty Management Plan, or UMP document, is a key component of the decision-making system used in oil and gas project management. It is not merely a table, but a structured database that serves as a living management tool throughout the project life cycle. In essence, the UMP document is a centralized road map for managing project uncertainties. If uncertainties are viewed as hazards along a ship's route, the UMP document is not just a list of threats, but a navigational chart showing how

Степень неопределенности		Степень влияния на все проектные решения (средневзвешенное)		
		Low	**Medium**	**High**
	High	Качество матрицы (при стимуляции ПЗ скважин)	Геомеханическая модель	Неоднозначный характер нефтенасыщения по площади и разрезу (объект X)
	High	Водопроявление > 10%	Распределение давления по зонам (платформа, борт, склон)	Малый объем ПГИ и керна на Объекте X
	High	Эффективность ППД	Неравномерная выработка запасов нефти по площади и разрезу	
	High		Выбытие скважин (в том числе из-за обводнения)	
	High		Зависимость ОФП, концевые точки)	
	High		Изменение обводненности продукции скважины	
	High		Распространение зон трещиноватости	
	High		Высокая вариабельность по проницаемости на Объекте X	
	High		Насыщенности по разрезу (зоны подвижной воды в объекте X), водонасыщенные линзы	
	High		Разница в пластовых давлениях объектов X и Y	
	High		Различие в ВНК объектов X и Y	
	High		Неподтверждение ВНК, что критично для бурения горизонтальных скважин	
	High		Завершение программы бурения	
	High		Результаты освоения скв. №1 влияющее на продолжение буровых работ и разработку объекта Y	
	High		Эффективность ППД закачкой газа (прорыв газа в доб.скв.)	
	High		Эффективность водоотдления	
	Mid	Выводы скважины на режим (длительность)	Неоднозначный характер нефтенасыщения по площади и разрезу (объект X)	Изменение продуктивности скважины во времени (PI)
	Mid	Фациальная изменчивость склоновой зоны: Прогноз сети естественных трещин и их связь с матрицей	Изменение проницаемости в процессе эксплуатации (причины, законы)	Зависимость проницаемости матрицы от кавернозных/трещинных интервалов (объект Y)
	Mid		Kv/Kh	
	Mid		Неясное распределение доломитизированных зон на Объекте Y	
	Mid		Продуктивность Объекта Y	
	Low	Межремонтный период скважин	Содержание CO_2, H_2S в продукции	
	Low	Изменение свойств пластовых флюидов резервуара	Межколонное давление (быстрый набор давления в 30 скважинах)	

Source: compiled by the authors.

Fig. 6. 3×3 Matrix of Average Impact on All Project Decisions

Степень неопределенности		Влияние на поддержание полки добычи после 2030 г.		
		Low	**Medium**	**High**
	High	Неравномерная выработка запасов нефти по площади и разрезу	Геомеханическая модель	Выбытие скважин (в том числе из-за обводнения)
	High	Распространение зон трещиноватости	Распределение давления по зонам (платформа, борт, склон)	Неподтверждение ВНК, что критично для бурения горизонтальных скважин
	High	Качество матрицы (при стимуляции ПЗ скважин)	Зависимость ОФП, концевые точки)	Завершение программы бурения
	High	Водопроявление > 10%	Изменение обводненности продукции скважины	
	High	Эффективность ППД	Различие в ВНК объектов X и Y	
	High		Результаты освоения скв.№1 влияющее на продолжение буровых работ и разработку объекта Y	
	High		Эффективность ППД закачкой газа (прорыв газа в доб.скв.)	
	Mid	Фациальная изменчивость склоновой зоны: Прогноз сети естественных трещин и их связь с матрицей	Неоднозначный характер нефтенасыщения по площади и разрезу(объект X)	Изменение продуктивности скважины во времени (PI)
	Mid		Изменение проницаемости в процессе эксплуатации (причины, законы)	
	Mid		Выводы скважины на режим (длительность)	
	Mid		Kv/Kh	
	Mid		Зависимость проницаемости матрицы от кавернозных/трещинных интервалов (объект Y)	
	Low	Межремонтный период скважин	Межколонное давление (быстрый набор давления, в 30 скважинах)	
	Low	Изменение свойств пластовых флюидов резервуара		

Source: compiled by the authors.

Fig. 7. 3×3 Matrix of Impact on the Decision "Plateau Duration"

to avoid them, strengthen the project's resilience, and respond effectively when they materialize.

To improve the uncertainty management process, the strategic uncertainty management plan may be consolidated. As a result, the original set of 29 uncertainties can be grouped into 8 aggregated uncertainties (Figure 9).

Thus, the strategic uncertainty management plan enables project teams and asset management to carry out the following effectively:

- prioritization of investment in information gathering. The UMP document helps answer the question: which geological studies, pilot tests, or market assessments should be funded first? Resources are directed not simply to areas of

Степень неопределенности	Влияния на утвержденный КИН: Low	Medium	High
High	Неравномерная выработка запасов нефти по площади и разрезу	Геомеханическая модель	Неоднозначный характер нефтенасыщения по площади и разрезу(объект Y)
High	Водопроявление > 10%	Распределение давления по зонам (платформа, борт, склон)	Выбытие скважин (в том числе из-за обводнения)
High	Эффективность ППД	Зависимость ОФП, концевые точки)	Распространение зон трещиноватости
High		Изменение обводненности продукции скважины	Малый объем ПГИ и керна на Объекте Y
High		Высокая вариабельность по проницаемости на Объекте Y	Неподтверждение ВНК, что критично для бурения горизонтальных скважин
High		Насыщенности по разрезу (зоны подвижной воды в объекте 2), водонасыщенные линзы	Завершение программы бурения
High		Разница в пластовых давлениях объектов X и Y	
High		Качество матрицы (при стимуляции ПЗ скважин)	
High		Различие в ВНК объектов X и Y	
High		Результаты освоения скв. №1 влияющее на продолжение буровых работ и разработку объекта Y	
High		Эффективность ППД закачкой газа (прорыв газа в доб.скв.)	
Mid	Выводы скважины на режим (длительность)	Неоднозначный характер нефтенасыщения по площади и разрезу (объект X)	Изменение продуктивности скважины во времени (PI)
Mid		Изменение проницаемости в процессе эксплуатации (причины, законы)	Зависимость проницаемости матрицы от кавернозных/трещинных интервалов (объект Y)
Mid		Kv/Kh	
Mid		Неясное распределение доломитизированных зон на Объекте Y	
Mid		Продуктивность Объекта Y	
Mid		Фациальная изменчивость склоновой зоны: Прогноз сети естественных трещин и их связь с матрицей	
Mid			
Low	Межремонтный период скважин	Межколонное давление (быстрый набор давления, около 30 скважин)	
Low		Изменение свойств пластовых флюидов резервуара	
Low			
Low			
Low			
Low			

Source: compiled by the authors.

Fig. 8. 3×3 Matrix of Impact on the Decision "Projected Water-Cut Profile"

# ID	Название неопределенности	Степень неопределенности	Степень влияния на решения	Название работы	Заказчик	Срок начала работы	Срок окончания работы	Ответственное лицо	Влияние на проектные решения
32	Изменение обводненности продукции скважин	H	M	Анализ динамики обводнения действующего фонда скважин. Определение источников воды	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / CAPEX в период Концессии / Удельная себестоимость добычи нефти / NPV (LF) / Продление периода "плато" добычи на высоком уровне
21	Изменение продуктивности скважины во времени (PI)	M	H	Анализ фактических данных добычи по скважинам, анализ данных ГДИ.	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / Продление периода "плато" добычи на высоком уровне
25	Выбытие скважин (в том числе из-за обводнения)	H	H	Анализ динамики обводнения действующего фонда скважин. Определение источников воды	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
18	Неоднозначный характер нефтенасыщения по площади и разрезу(объект Y)	H	H	Анализ результатов бурения и опробования объекта Y в скв. №1	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / NPV (LF) / Продление периода "плато" добычи на высоком уровне
41	Зависимость проницаемости матрицы от кавернозных/трещинных интервалов (объект Y)	M	H	Анализ результатов бурения и опробования объекта Y в скв. №1	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / NPV (LF)
45	Неподтверждение ВНК, что критично для бурения горизонтальных скважин	H	H	Определение источников воды, изучение данных ГИС. Проведение новых ГИС в последующих скважинах	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Поддержание полки добычи после 2029 г. / Утвержденный КИН / NPV (LF) / Продление периода "плато" добычи на высоком уровне
20	Геомеханическая модель	H	M	Создание геомеханической модели	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / CAPEX в период Концессии / NPV (LF) / Продление периода "плато" добычи на высоком уровне
17	Неоднозначный характер нефтенасыщения по площади и разрезу(1-ый объект)	M	H	Уточнение геологической модели объекта X.	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / NPV (LF) / Продление периода "плато" добычи на высоком уровне
44	Различие в ВНК объектов X, Y	H	M	Уточнение положения ВНК для объектов и различных зон пласта-коллектора	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / NPV (LF) / Продление периода "плато" добычи на высоком уровне
28	Kv/Kh	M	M	SCAL-анализ	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
30	Межколонное давление (быстрый набор давления в 30 скважинах)	L	M	Анализ работающего фонда скважин с МКД. Анализ причин проявления МКД (тех.состояния колонны, проведения шумометрии)	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
48	Эффективность ППД закачкой газа (прорыв газа в доб.скв.)	H	M	Выполнение расчетов на ГДМ с последующей выработкой рекомендаций по изоляция зон газопроявления.	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
19	Изменение проницаемости в процессе эксплуатации (причины, законы)	M	M	SCAL-анализ	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / Продление периода "плато" добычи на высоком уровне
34	Малый объем ПГИ и керна на Объекте Y	H	H	Переобработка старых материалов, выполнение нового комплекса ПГИ, SCAL-анализ	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
46	Завершение программы бурения	H	H	Разработка стратегии развития месторождения в текущих планах Оператора после 2030 г.	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г. / CAPEX в период Концессии / Удельная себестоимость добычи нефти / NPV (LF) / Продление периода "плато" добычи на высоком уровне
23	Распределение давления по зонам (платформа, борт, склон)	H	M	Разработка программы ГДИ, построение карт изобар, актуализация ГДМ	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Продление периода "плато" добычи на высоком уровне
42	Фациальная изменчивость склоновой зоны: Прогноз сети естественных трещин и их связь с матрицей	M	M	Уточнение геологической модели объекта Y. для определения распространения зон трещиноватости в межскважинном пространстве».	ПАО	2025	2028	ЗГД по геологии и и разработке	НГЗ / Утвержденный КИН
31	Изменение свойств пластовых флюидов резервуара	L	M	Регулярный отбор проб и PVT-анализ	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
22	Содержание CO2, H2S в продукции на объекте Y	L	M	Анализ результатов опробования объекта Y в скв. №1 и с возможным повторным отбором PVT проб.	ПАО	2025	2028	ЗГД по геологии и и разработке	CAPEX в период Концессии / Удельная себестоимость добычи нефти / NPV (LF)
29	Зависимость ОФП, концевые точки)	H	M	SCAL-анализ	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Накопленная добыча нефти до 2033 г.
49	Эффективность водоотделения	H	M	Проработка вопроса запуска простаивающего обводненного фонда скважин	ПАО	2025	2028	ЗГД по геологии и и разработке	CAPEX в период Концессии / Удельная себестоимость добычи нефти / NPV (LF)
33	Распространение зон трещиноватости	H	H	Уточнение геологической модели объекта Y. для определения распространения зон трещиноватости в межскважинном пространстве».	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН / Продление периода "плато" добычи на высоком уровне
43	Качество матрицы (при стимуляции ПЗ скважин)	H	M	Подбор технологии и методов ПНП	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
36	Неясное распределение доломитизированных зон на Объекте Y	M	M	Построение детальной структурно-тектонической модели, структурно-парагенетический анализ, атрибутный анализ сейсмических данных, сопоставление сейсмического отклика с результатами скважинных исследований	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
37	Продуктивность Объекта Y	M	M	Анализ результатов бурения и опробования объекта Y в скв. №1	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
47	Результаты освоения скв. №1 влияющее на продолжение буровых работ и разработку объекта Y	H	M	Анализ результатов бурения и опробования объекта Y в скв. №1	ПАО	2025	2028	ЗГД по геологии и и разработке	Поддержание полки добычи после 2029 г. / Утвержденный КИН / Продление периода "плато" добычи на высоком уровне
35	Высокая вариабельность по проницаемости на Объекте Y	H	M		ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
38	Насыщенности по разрезу (зоны подвижной воды в объекте Y), водонасыщенные линзы	H	M	Переобработка старых материалов, выполнение нового комплекса ПГИ	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН
40	Разница в пластовых давлениях объектов X и Y	H	M	Рассмотрение возможности раздельной добычи	ПАО	2025	2028	ЗГД по геологии и и разработке	Утвержденный КИН

Source: compiled by the authors.

Figure 9. Strategic (Detailed) Uncertainty Management Plan

limited clarity, but to those where uncertainty has a material impact on project value and can realistically be reduced;

- support for key decisions. Before any major investment decision, including the Final Investment Decision (FID), management reviews the strategic uncertainty management plan, that is, the UMP document. If it still contains high-priority uncertainties for which no action plan has been developed, the decision is postponed until those uncertainties have been addressed;
- development of a flexible and robust project plan. The UMP document helps make the project more resilient under different scenarios. The field development plan is selected not for a single average case, but in a way that delivers acceptable results under a pessimistic scenario while preserving upside under an optimistic one;
- transparent communication and accountability. The UMP document serves as a single source of truth for geologists, engineers, economists, and senior managers. It ensures that all participants understand which uncertainties and risks are most important, who is responsible for them, and what is being done to manage them. This helps avoid situations in which everyone was aware of a risk, yet no one was accountable for addressing it.

Conclusion

The Uncertainty Management Plan (UMP) is an effective practical tool that transforms uncertainty management from an abstract concept into concrete, measurable, and actionable steps. It serves as the project's decision-support center, where economic indicators and the selected strategy are brought together to enable sound decision-making.

Experience gained from UMP workshops on both Russian and international projects shows that, despite the rigor of uncertainty and risk analysis, actual outcomes for many projects differ substantially from what was anticipated at the time of project approval [Bickel, Bratvold, 2007; Ward, Whitaker, 2016]. This once again confirms that, in major oil and gas projects, it is not enough simply to reduce uncertainty. Project teams must be able to make sound decisions under conditions of uncertainty. At the same time, a sound decision is not necessarily an ideal one, but one that is sufficiently well founded, timely, and adaptive. Such a decision means taking the best possible next step based on the information currently available. Rather than searching for a single correct answer, project teams prepare for several possible scenarios. When one of these scenarios materializes, the company already has either a ready response plan or at least a clear understanding of its first steps. As a result, it is not paralyzed by uncertainty and can respond quickly.

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