



REQUEST FOR PROPOSAL

Updated seismic PSA feasibility study

Non-Nuclear Safety Related

Specification Number
SP-ES-1475

KRŠKO NUCLEAR POWER PLANT

Revision 1
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TABLE OF CONTENTS

1	BACKGROUND.....	3
2	SCOPE OF SERVICES.....	4
3	SAFETY CLASSIFICATION OF SERVICES	7
4	DESIGN INPUTS	7
5	APPLICABLE DESIGN CONTROL PROGRAM	9
6	APPLICABLE CODES, STANDARDS, AND DESIGN CRITERIA.....	9
7	AFFECTED SYSTEMS	9
8	IDENTIFICATION OF AFFECTED EQUIPMENT	9
9	REVIEW AND/OR VERIFICATION OF SERVICES	9
10	SCHEDULE	9
11	STATUS REPORTING REQUIREMENTS.....	10
12	NEK RESPONSIBILITIES	10
13	WORK SCOPE CHANGES.....	10
14	DELIVERABLES	10
15	RECORDS	10
16	NEK CONTACTS	11
17	CONTRACTOR TECHNICAL APPROACH	11
18	ACCESS TO CONTRACTOR FACILITY AND DOCUMENTS	11
19	SUBCONTRACTED WORK.....	11
20	QUALITY ASSURANCE REQUIREMENTS	11
21	NEK PROPRIETARY DATA	11

1 BACKGROUND

Results of revision 1 of new probabilistic seismic hazard assessment (PSHA) for Krško nuclear power plant (NEK) and Krško nuclear power Plant 2 (JEK 2) have been issued in 2024 Ref. [4.1]. Results of new PSHA are (in short) seismic hazard curves and uniform hazard spectra (UHS) for selected control points, i.e., free surface, 12 m and 20 m below free surface and deeper points – at soil layers representing rock equivalent material.

New UHS has different shape comparing to UHS from 2004, Ref. [4.2], with the peak at around 5 Hz. New UHS may have effect on seismic demand/accelerations of structures, systems and components with natural frequencies between 3 and 10 Hz. Mean hazard curves and corresponding uncertainties related to seismic hazard for earthquakes with high return periods are significantly higher based on new PSHA comparing to previous PSHA from 2004. Higher spectral accelerations at 5 Hz, increased hazard and larger uncertainties have direct effect on fragility parameters and results of SPSA (CDF values).

This specification sets forth the scope of services to conduct a feasibility study identifying actions needed for updating seismic probabilistic safety assessment for Krško nuclear power plant given a new seismic hazard input. The work performed should follow the latest industry state-of-practice and methodologies implemented in the United States and regulations per U.S. NRC.

2 SCOPE OF SERVICES

The Contractor's scope of services is to conduct a feasibility study identifying set of actions to update seismic probabilistic safety assessment (SPSA) of Krško nuclear power plant given a new seismic hazard (see Figures 1–4). The proposed option to identify the set of actions to update SPSA is to run several sensitivity analyses to understand and identify those contributors to the SPSA which have potential greater impact to both models and/or methodology.

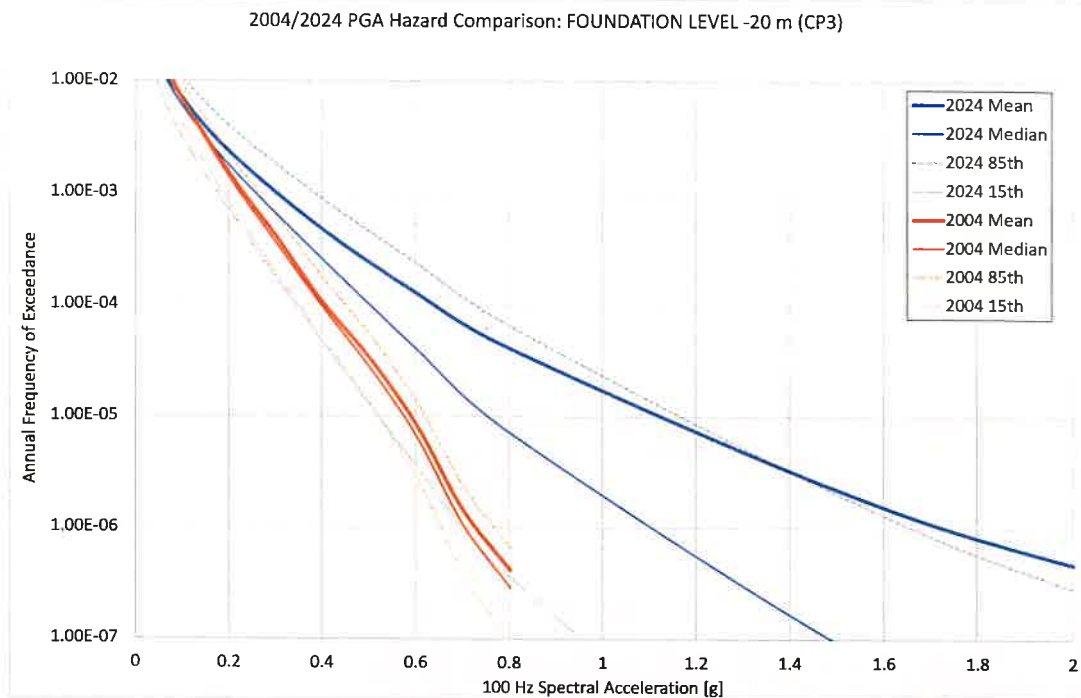


Figure 1: Comparison of new foundation level (-20m) hazard percentile PGA curves (2024), blue curves, with old foundation level (-20m) hazard curve (2004), orange curves.

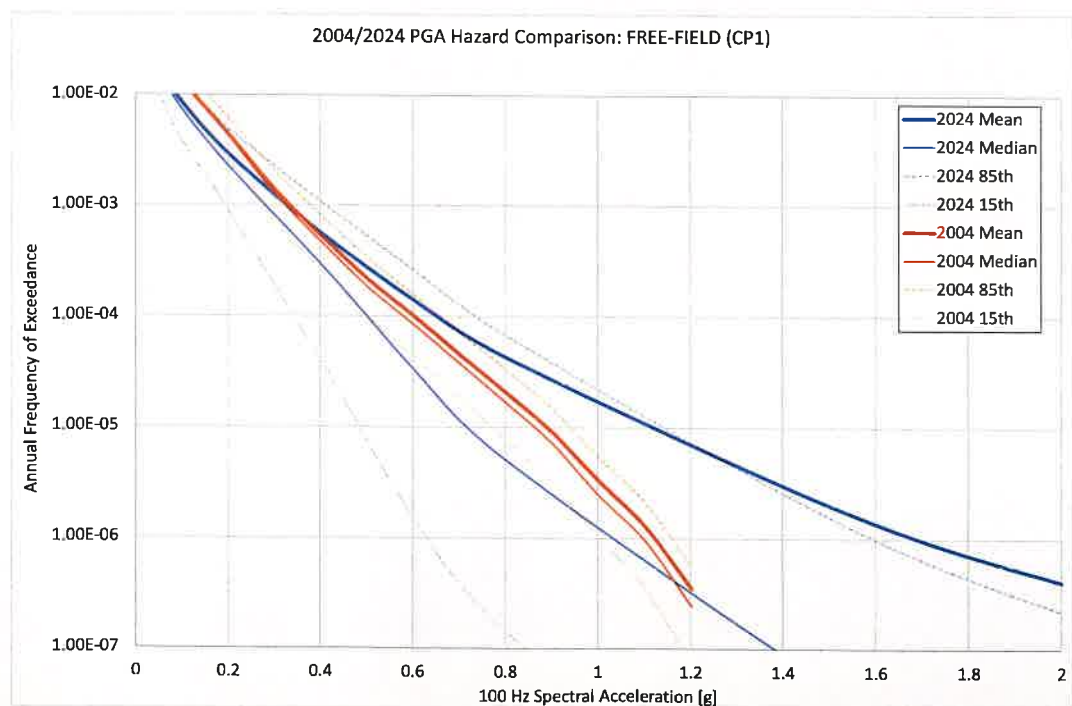


Figure 2: Comparison of new free-field hazard percentile PGA curves (2024), blue curves, with old free-field hazard curve (2004), orange curves.

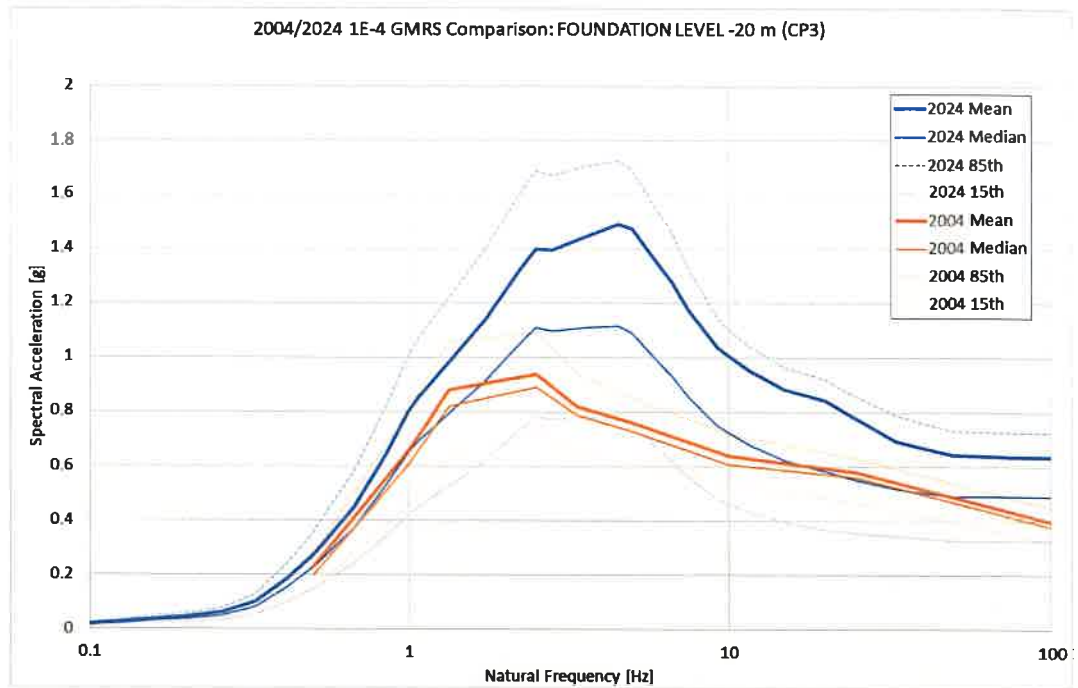


Figure 3: Comparison of new foundation level (-20m) Uniform Hazard Spectra (2024), blue curves, with old foundation level (-20m) UHS (2004), orange curves.

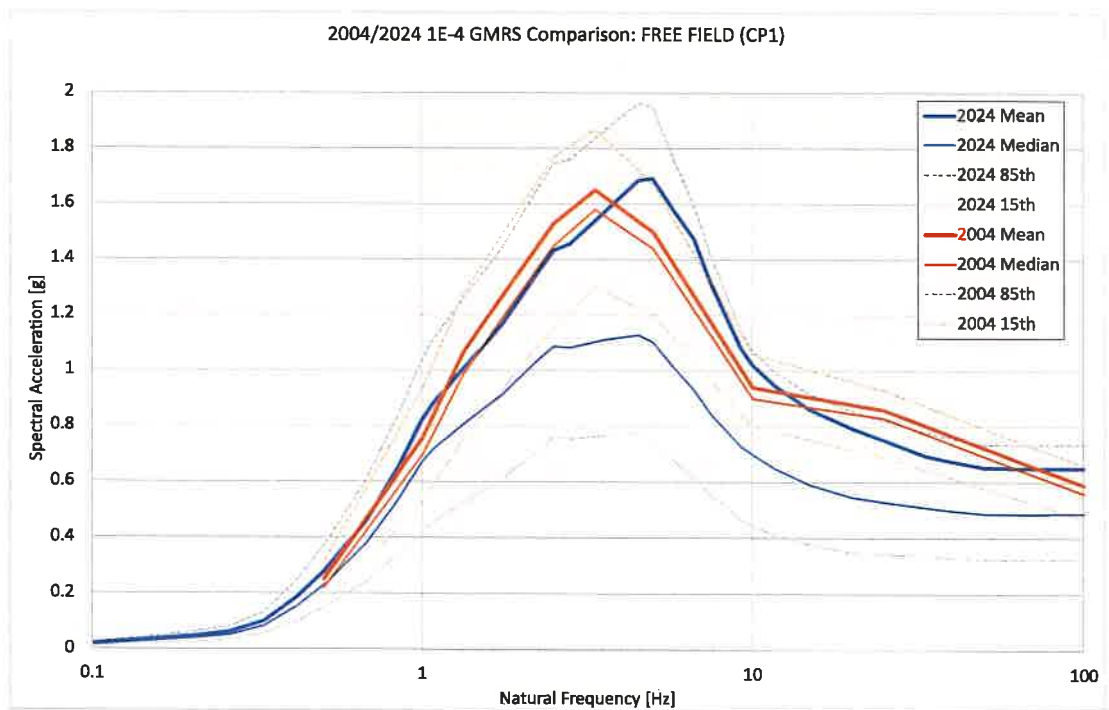


Figure 4: Comparison of new free-field Uniform Hazard Spectra (2024), blues curves, with old free-field UHS (2004), orange curves.

The change in new UHS (2024) comparing to previous UHS (2004) is both in spectra shape and in PGA level. For the reference earthquake, the median UHS is taken into account in the reference seismic analysis. Based on the comparison between UHS (2024) and UHS (2004), new UHS exceed existing one in natural frequencies between 1.5 Hz and 20 Hz. Some frequencies will be filtered through the building response. It is expected that equipment with natural frequencies between 3 – 10 Hz will be affected (forces increased). In addition to revised seismic forces, we should also consider re-evaluating existing methodology for fragility assessments in order to potentially eliminate conservatism in the existing fragility assessments. The scope of work for this feasibility study divided on different phases as follows:

Task 1: Gain knowledge of existing SPSA and updated seismic hazard:

- a) Get access and familiarize with existing SPSA system model and methodologies, and familiarize with existing plant systems, Ref. [4.3 – 4.7]. Existing SPSA report, models and input references are available for use in scope of this project. In existing SPSA, Requirements of the ANS standard were met for Capability Category II (ANS (2003), "External Events PRA Methodology Standard," ANSI/ANS 58.21, 2003, American Nuclear Society, November 2003.).
- b) Gain knowledge of existing building seismic response analyses and fragility calculations, Ref. [4.8 – 4.31].
- c) Get knowledge of both 2004 and 2023 seismic hazard curves and uniform hazard spectra, and assess changes in seismic hazard, site response spectra and foundation input response spectra comparing to those from 2004, (Ref. [4.1 – 4.2]).

Task 2: Sensitivity analyses:

- d) Re-run the current Krško model with current hazard and current fragilities and calculated core damage frequency in order to define the baseline. The results must technically match the results of existing SPSA analyses of NPP Krško. Note that NEK is using software RiskSpectrum, version 1.2.1., for plant risk analysis.
- e) Perform initial scaling of the fragilities based on new hazard, and re-run the model with new hazard and scaled fragilities. Perform risk quantification and record top contributors to CDF with consideration of:
 - o Updated (2023) PGA mean hazard curve.
 - o Initially scaled fragilities (median capacities and beta values) based on new 2023 uniform hazard spectra (estimated based on changes in UHS spectra). Note that 3D Finite Element Model of the NEK buildings is not available.
 - o Margin resulting from using more realistic spectra like conditional mean spectra in structural seismic response analysis (instead UHS spectra), if applicable.
 - o Other contributors as suggested by Contractor.
- f) Seismically induced fires are addressed in fire study (currently in update process and will be addressed separately – not in scope if this work). Please consider facts related to seismically induced flooding as follows. About the seismically induced internal flooding, only fire protection lines are not seismically designed. All equipment is protected from spraying, raised on pedestals and drainage is capable to drain full Fire Protection flow. Intermediate Building is separated/isolated from Turbine Building - Secondary side and also drainage check valves are seismically designed and regular surveillance is performed. The top contributing parameters that have the greatest influence on the results as identified in 2d and 2e above can be selected from different areas, such as:
 - o SPSA model, CDF calculations (interval-based vs. point estimate CDF)
 - o building seismic response methods / ISRS calculations (3D FEM of NEK buildings are not available),
 - o failure mode definitions,

- seismic fragility parameters / partial correlations.
- g) Given the insights of the baseline runs performed in 2d to 2f above, a list of potential fragility and/or model refinements should be recommended. Walkdowns shall be performed here in support to the review of the fragilities for the most important contributors.
- h) Estimate SPSA plant response, building seismic response and fragility calculation to get insights into effects of top contributors on SPSA results (seismic core damage frequency) according to 2g above. Engineering judgement may be used.
- i) Record the effect of potential refinements on CDF and plant response insights as a result of 2h.

Task 3: Establish path forward for SPSA update:

- j) Issuance of Preliminary and Final reports of Tasks 1 and 2 above, with prioritized recommendations.

3 SAFETY CLASSIFICATION OF SERVICES

This order is classified as non-nuclear safety related (NNSR).

4 DESIGN INPUTS

The potential Contractor shall prepare the list of any necessary inputs (drawings, calculation notes, reports, documents, USAR sections) needed for performing the requested scope of work and include it in the proposal. NEK will inform the potential Contractor about availability of such documents from the list and terms under which they can be handed over, solely as required inputs for the scope of services. Please, note that some of these documents may be available for review only at NEK premises.

Available input documents:

- 4.1 Probabilistic Seismic Hazard Analysis for Krško Nuclear Power Plant (NEK) and Krško Nuclear Power Plant 2 (JEK 2), Rizzo International, Inc., Geološki Zavod Slovenije, Norman A. Abrahamson, Inc., Project No. 20-6146, Revision 2, October 2024.
- 4.2 Revised PSHA for NPP Krško site, PSR – NEK – 2.7.2, University of Ljubljana, Faculty for Civil and Geodetic Engineering, Institute of Structural Engineering, Earthquake Engineering and Construction IT, Environmental Agency of Republic of Slovenia, Office of Seismology, Geological Survey of Slovenia, Geomatrix Consultants, Revision 1, 2004.
- 4.3 Krško SPSA, Task 1, Seismic Fragilities and Specifications for Risk Model Updates, R-1236928-1520: SPSA-ABS-NEK-2004-001, ABSG Consulting Inc., Revision 1, August 2004.
- 4.4 Seismic Probabilistic Safety Assessment of Krško Nuclear Power Plant, Level 1 and Level 2, R-1236928-1543: SPSA-ABS-NEK-2004-003, ABSG Consulting Inc., Revision 2, November 2004.
- 4.5 Update of Selected Fragilities for Krško NPP Seismic PSA, R-1208545-1486, ABSG Consulting Inc., July 2003
- 4.6 Implementation of DG3 modification into NEK PSA model, Nuclear Power Plant, NEK ESD TR-19/12, Revision 0, NEK, 2019
- 4.7 Evaluation of New RS PSAP NEK Baseline Model "NEKC34", Nuclear Power Plant, NEK ESD-TR-07/24, Revision 0, 2024.
- 4.8 Probabilistic seismic response analysis for Krško Nuclear Power Plant, EQE International, Report No. 52177-R-001, August 1995.

- 4.9 Scaling of Probabilistic Response Spectra to Reflect Updated 2002 Seismic Hazard Data, ABSG Consulting Inc., SPSA-ABS-NEK-2003-002, Revision 0, November 2003.
- 4.10 Update of Selected Fragilities for Krško NPP Seismic PSA, ABSG Consulting Inc., Report No.: R-1208545-1486, July 2003.
- 4.11 Fragility of 400 V Switchgears, Krško IPEEE, EQE Engineering, Report No.: 52177-C-002, Revision 0, 5/3/95.
- 4.12 CCW Pump Fragility, Krško IPEEE, EQE Engineering, Report No.: 52177-C-004, Revision 0, 5/3/95.
- 4.13 Fragility of 6.3 kV Switchgears, Krško IPEEE, EQE Engineering, Report No.: 52177-C-006, Revision 0, 5/11/95.
- 4.14 Fragility of 6.3 kV / 400 V Transformers & Pressureizer Heater Transformer, Krško IPEEE, EQE Engineering, Report No.: 52177-C-008, Revision 0, 5/4/95.
- 4.15 Fragility of piping and in-line components, Krško IPEEE, EQE Engineering, Report No.: 52177-C-010, Revision 0, 5/11/95.
- 4.16 Fragility of Essential Service Water Pumps, Krško IPEEE, EQE Engineering, Report No.: 52177-C-011, Revision 0, 5/11/95.
- 4.17 Reactor Building Seismic Fragility, Krško IPEEE, EQE Engineering, Report No.: 52177-C-014, Revision 0, 5/11/95.
- 4.18 Condensate Storage Tank Seismic Fragility, KRŠKO Seismic PSA, ABS Consulting, Report No.: 1236928-C-003, Revision 0, 12/17/03.
- 4.19 Refueling Water Storage Tank Seismic Fragility, KRŠKO Seismic PSA, ABS Consulting, Report No.: 1236928-C-004, Revision 0, 12/17/03.
- 4.20 Fragility of Diesel Fuel Oil Tank, KRŠKO SPSA Update, ABS Consulting, Report No.: 1236928-C-010, Revision 0, 03/23/04.
- 4.21 Anchorage of Electrical Cabinets, KRŠKO SPSA Update, ABS Consulting, Report No.: 1236928-C-011, Revision 0, 03/24/04.
- 4.22 DG Control Panel Fragility, KRŠKO SPSA Update, ABS Consulting, Report No.: 1236928-C-018, Revision 0, 04/23/04.
- 4.23 Equipment Fragility Analysis, Krško IPEEE, Westinghouse Energy Systems Europe S.A., Report No. CN-1549, 1st Part, July 1995.
- 4.24 Equipment Fragility Analysis, Krško IPEEE, Westinghouse Energy Systems Europe S.A., Report No. CN-1549, 2nd Part, July 1995.
- 4.25 Krško IPEEE - Walkdown Report for Outside Containment Equipment, Westinghouse Energy Systems Europe S.A, Report No.: IPE-W-NEK-93-134, Revision 1, July 1994
- 4.26 Seismic/LOCA Analysis of the KRŠKO 16X16 Standard Fuel Assemblies, Westinghouse, Report No.: PD1-99-110, July 14, 1999.
- 4.27 Krško SPSA – RCS Piping and Component Supports Fragilities, Westinghouse Electric Company LLC, Report No.: WB-CN-ENG-03-72, Revision 0, December 2003.
- 4.28 Krško SPSA – CRDMs and Head Assembly fragilities, Westinghouse Electric Company LLC, Report No.: WB-CN-ENG-03-74, Revision 0, December 2003.
- 4.29 Krško SPSA – Reactor Vessel Internals and Fuel Assemblies Seismic Evaluation, Westinghouse Electric Company LLC, Report No.: WB-CN-ENG-03-82, Revision 0, January 2004.
- 4.30 Krško SPSA – Equipment Fragility Update, Westinghouse Electric Company LLC, Report No.: WB-CN-ENG-03-84, Revision 0, January 2003.
- 4.31 Krško SPSA – Medium Bore Piping Seismic Fragility, Westinghouse Electric Company LLC, Report No.: WB-CN-ENG-03-85, Revision 0, January 2003.

5 APPLICABLE DESIGN CONTROL PROGRAM

All services shall be provided according to Chapter 6 and applicable Contractor's quality assurance program. If Contractor does not have such design control program, the NEK quality assurance program must be applied.

6 APPLICABLE CODES, STANDARDS, AND DESIGN CRITERIA

Existing NEK PSA is in accordance with Ref. [6.1]. The work performed herein shall follow the latest industry state-of-practice and methodologies implemented in the United States and regulations per U.S. NRC. The methodology shall be consistent also with Ref. [6.2] with consideration of requirements for Capability Category 2.

- 6.1 ANSI/ANS 58.21, 2003, External Events PRA Methodology Standard, Capability Category 2.
- 6.2 ASME/ANS RA-S-1.1-2022, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications

7 AFFECTED SYSTEMS

Not applicable.

8 IDENTIFICATION OF AFFECTED EQUIPMENT

Not applicable.

9 REVIEW AND/OR VERIFICATION OF SERVICES

NEK will perform internal preliminary and final review. The Contractor shall prepare response to preliminary review, comment it and take it into full consideration as part of the contracted services.

10 SCHEDULE

Item	Requirement	Schedule
Phase 1	Determination of the methodology and preliminary technical report	T0 + 3 months
	NEK review/comments	T0 + 4 months
Phase 2	Final technical report	T0 + 5 months
	Final NEK review and approval	T0 + 6 months

T0 - date of contract signature by both parties

All of above deliverables shall be completed and submitted to NEK for review. NEK will formally respond with comments and/or acceptance to each technical report within on month.

11 STATUS REPORTING REQUIREMENTS

Regular communication will be used during the project. The communication channels are going to be defined on the kick-off meeting. Formal status reports are not required.

12 NEK RESPONSIBILITIES

NEK will provide documents according to Section 4 of this technical specification

13 WORK SCOPE CHANGES

The Contractor shall notify NEK about any required scope change, including the reasons for such request.

NEK shall provide the formal response within eight working days.

14 DELIVERABLES

The Contractor shall prepare and hand over the following deliverables:

Deliverable Item:	No. of hard copies	No. of el. copies (docx and pdf format)
Preliminary Report with all calculation files and models	1	1
Final Report with all calculation files and models	1	1

All deliverables must be reviewed and approved by NEK. NEK will formally review and comment any of deliverables within one month. Contractor shall resolve all open items based on NEK comments. Each deliverable shall be issued in two 1 month after obtaining NEK approval. All documentation shall be written in English. Electronic versions shall be provided in MS Word (.docx) format, as well as searchable Adobe Acrobat (.pdf) format.

15 RECORDS

Not applicable.

16 NEK CONTACTS

Contractor shall co-ordinate all technical and scheduling matters with the assigned NEK project manager and responsible engineer.

NEK technical contacts:

Responsible engineer:

Daniel Celarec

Phone: ++ 386 7 4802 206

E-mail: daniel.celarec@nek.si

Deputy Responsible engineer:

Rudolf Prosen

Phone: ++ 386 7 4802 533

E-mail: rudolf.prosen@nek.si

17 CONTRACTOR TECHNICAL APPROACH

Not applicable.

18 ACCESS TO CONTRACTOR FACILITY AND DOCUMENTS

Not Applicable.

19 SUBCONTRACTED WORK

The Contractor shall not subcontract any portion of the required services without the written approval of the NEK. Subcontractors will be required to be technically qualified to satisfy all NEK criteria.

20 QUALITY ASSURANCE REQUIREMENTS

All work shall be prepared according to Contractor's QA program.

21 NEK PROPRIETARY DATA

NEK has a proprietary interest in all drawings, design, specifications, documents, information and know-how that may be furnished pursuant contract execution. Also, NEK has a proprietary interest in any know-how, improvement, discovery, and invention which may be made, developed, or conceived in the performance of work hereunder or which may arise or result therefrom (hereinafter collectively referred to as the "Information"). All such information shall be considered to be proprietary of NEK.

The right to use any such Information shall be restricted to the Contractor only, for its internal use, and shall be entirely tied to the performance of the Contract.

All such Information is subject to the confidentiality provision.