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Technical specifications

for data delivery from geothermal projects subsidised by the Swiss Federal Office of Energy SFOE

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Glossary

Geodata or geological information: data and information concerning the geological subsuface, including its structure, nature and properties, its past and present use, its economic, societal and scientific value, as well as past, present and potential geological processes.

Prospection or prospecting: covers investigations which on the one hand serve to characterize the subsurface of a presumed geothermal reservoir and, on the other hand, determine the above-ground site and the underground landing point of an exploration well.

Development: covers exploration by drilling and extracting hot water and the possibility of returning the extracted water into the geothermal reservoir.

Primary geological data: data in the sense of direct measurements or descriptions, surveys, documentation of geological features, including unprocessed signals and measurement values, lithological and geotechnical descriptions of core and drill cuttings, outcrop maps, laboratory analyses;

Processed primary geological data: geological data that have been processed for interpretation, including processed geophysical data and borehole profiles;

Secondary geological data and information: geological data and information resulting from the interpretation of primary geological data and processed primary geological data, including interpretations of geophysical data, geological maps, geological sections, geological models, etc.

1 Introduction

The Swiss Confederation, via the Swiss Federal Office of Energy (SFOE), supports the development of geothermal energy through subsidy programs aiming at partially transferring the geological risks to the public, in particular during the prospection and subsurface development phases where these risks are the highest. In return, according to the Energy and the CO_2-Acts, the recipient of a risk mitigation measure from the Confederation must transfer the collected, processed and interpreted geodata to the Confederation and to the canton where the project is located. Being the federal competency center for geodata, the Federal Office of Topography (swisstopo) collects the data according to its technical specifications.

The purpose of this document is to inform applicants about swisstopo's technical specifications according to which data are to be delivered, as well as about the publication of these data.

2 Legal bases

According to the Geological Survey Ordinance (OGN)[1], data are distinguished into primary, processed primary and secondary data and information. Primary and processed primary data must be published, but secondary geological data and information will not be published, unless the data owner gives permission to swisstopo. All data can be used by swisstopo for its own purposes.

The relevant ordinances[2] state under the chapter geodata that:

"The applicant shall make the respective geodata available free of charge to swisstopo and to the canton where the prospecting and development is taking place in accordance with the technical specifications of swisstopo no later than six months after the data was collected."

"swisstopo may use and process these geodata in accordance with the objectives of the Geoinformation Act[3] of 5 October 2007 and the Geological Survey Ordinance[4] of 21 May 2008; the cantons with prospecting and development sites may do so in accordance with their respective regulations."

The ordinances also state for the subsidized projects that:

"It shall make the primary and the processed primary geodata available to the public within 24 months after completion of prospecting and within 12 months after completion of development."

Data acquired or developed with public money must benefit the community, facilitate future projects and reduce risks, and therefore they must be published.

The description of the context in which the data were acquired (methods, instruments, parameters, particularities, etc.) does not constitute an interpretation. Without this information, raw and processed data are practically unusable.

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[1] Art. 2 Definitions, RS 510.624

[2] Annex 2.5 art. 5 from the Renewable Energy Ordinance, for electrical projects that have received a contribution
Annex 12, art. 5 from the CO_2 Ordinance for projects involving the direct use of geothermal energy to produce heat that have received a contribution
Annex 2, art. 4 from the Energy Ordinance, for electrical projects that have received a guarantee.

[3] RS 510.620

[4] RS 510.624

This document describes the technical specifications as stated in the ordinances. These technical specifications cannot provide an exhaustive list of every conceivable type of data to be acquired, but they do provide a detailed framework for the most common ones that are likely to be acquired as part of these projects.

Thereby, completion of prospection means:

- geophysical data should be made available to the public 2 years after the end of the geophysical survey (last day of acquisition)
- prospection borehole data should be made available 2 years after the end of the drilling operations (end of logging operations)

Completion of development means:

- borehole data should be made available to the public 1 year after the end of the drilling operation (end of wireline logging operations)

The decision whether the work in planning is part of the prospection phase or the development phase is made as part of the contract with the SFOE.

3 Prospection phase

Prospecting covers investigations which on the one hand serve to characterize the subsurface of a presumed geothermal reservoir and, on the other hand, determine the above-ground site and the underground landing point of an exploration well.

Usually, geophysical methods are applied but other methods for gathering data such as prospection wells, mapping or hydrochemical sampling can also be envisaged during prospection.

In the following, we distinguish between data to be delivered by the project owner and data to be published by swisstopo. Data to be published are listed in Chapter 7 and in Annex B.

3.1 Data to be delivered

At the end of the prospection phase, all related data are to be delivered to swisstopo.

Prospection data specified in this document:

- 2D or 3D reflection seismic survey, including all supplementary measurements (for example LVL (low velocity layer), uphole wells…). See Chapter 3.2.
- Prospection wells → check boreholes data specifications in Chapter 4.

Other possible prospection data not specified in this document

- Refraction seismic survey
- Passive seismic (for example microseismicity, ambient noise tomography)
- Gravimetry/magnetic survey
- Electromagnetic survey
- Geoelectric survey
- (Sub-)Surface fluid analyses
- Structural measurements
- Surface samples mineralogy, petrography, chemistry, petrophysics
- 3D models and explanatory reports
- Etc.

Annex A “Prospection data inventory” must be submitted by the operator and contain the following information:

- The “Data” sheet is the inventory list of all files provided to swisstopo
- The “Metadata” sheet compiles a set of basic information

3.2 Reflection seismic survey deliverables specifications

The figure below shows a simplified sketch of a conventional reflection seismic data acquisition/processing flow in the context of prospection. The various project stages produce 4 datasets (in blue) that are intended for delivery to swisstopo.

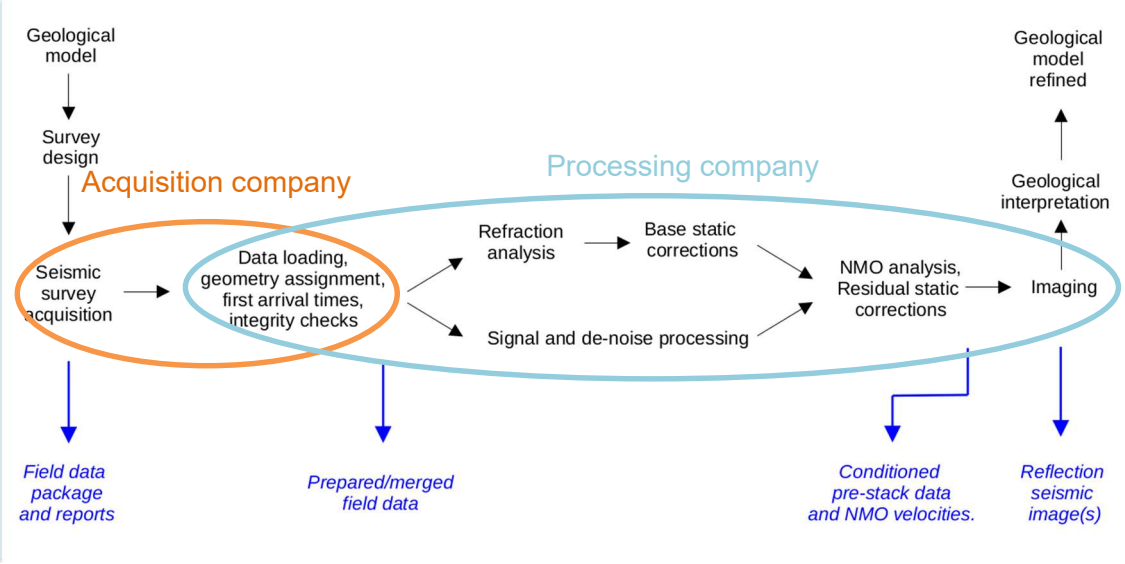


Figure 1: Seismic survey workflow and datasets to be provided to swisstopo

For seismic surveys, the following datasets are to be provided:

- Set 1: Field data package (from the seismic data acquisition company)
- Set 2: Prepared/merged field data (from data processing or acquisition)
- Set 3: Conditioned pre-stack data and NMO velocities (from data processing)
- Set 4: Final image(s) in time and if available in depth (from data processing)

The datasets must adhere to the technical details and properties given below.

3.2.1 Field data package

The field data package shall include the elementary required material as transferred to the processing center. Typically, that includes:

- Shot records (or shot-record-like data extract from continuous recordings) associated at least with the field record number, source initiation time stamp, channel and/or receiver IDs
- Geometry data: source and receiver point data and relation records that are quality-checked and integrity-checked
- Observer logs
- Field operation report that also covers the topic of surveying
- Description of shot record and geometry data

This package is intended for offline archiving at swisstopo.

Data formats shall be:

- Seismic data: SEGY (preferred), SEGD or mSEED
- Geometry data: SPS
- Observer logs: text, spreadsheet or Shapefile
- Field operation report: PDF

3.2.2 Prepared/merged field data

This dataset comprises geometry-assigned field data after minimal signal processing for conversion to minimum phase (see details below) and association with first arrival times and optional complementary information.

The format of this dataset is SEGY. All geometry and complementary information shall be stored in the trace headers. Values (coordinates, times) shall be scaled so that a sufficient

accuracy is maintained by the integers used in the trace headers (e.g. scale first arrival times to 10*ms).

Signal processing of these data shall be reduced to the minimum that is necessary in providing minimum-phase signal characteristics. Typically, this involves designature (deconvolution to remove the embedded wavelet) and conversion to minimum-phase of vibro- or airgun-source data. No such signal processing involves data from explosive sources. Signal processing at this stage shall not include complementary steps such as geo/hydrophone adjustments, vibro/explosive adjustments, phase adjustments. Stacking of multiple (repeated) sources per source point should preferably not be applied.

The purpose of this dataset at swisstopo is to make available a complete, geometry-ready and raw-min-phase-signal dataset for signal/denoise processing, refraction analysis and waveform inversion studies.

Travel time reference of these data is the original acquisition surface (no static corrections applied).

Geometry information shall be provided by trace headers and shall include:

- Shot/source ID, field record number, FFID (Field File Identification)
- Source initiation time stamp
- Source point identification: line, point, index
- Source point position: easting, northing, ground elevation, shot hole or airgun depth
- Source type identification (if different types or configurations were used)
- Source uphole time
- Source usage flag: e.g. production data, test record, void record etc.
- Receiver point identification: line, point, index
- Receiver point position: easting, northing, ground elevation
- Receiver type identification (if different types or configurations were used)
- Receiver usage flag: e.g. production data, void channel, aux channel etc.
- Per trace: first arrival time

The following complementary information may also be delivered:

- Midpoint geometry: CDP, IL, XL numbers, bin center easting and northing coordinates, if a binning scheme is available (i.e. bin assignment already applied).
- Source static corrections (base and residual), not applied, but values stored in headers
- Receiver static corrections (base and residual), not applied, but values stored in headers
- Per trace: source/receiver offset and azimuth

Documentation shall include:

- description of all processing applied, starting from field data package
- exact description of signal processing applied
- description of data format
- description of trace headers
- minimum-phase and deconvolution filters (incl. tables as part of the description)

3.2.3 Conditioned pre-stack data and NMO velocities

This product constitutes pre-processed pre-stack data, which have been subject to all static corrections, signal- and de-noise processing. These data were NOT subject to data-interpolation, geometry-regularization, any multi-trace coherency or S/N enhancement, dynamic corrections (NMO, redatuming) and any form of imaging. These data are field traces after elementary data conditioning, and each trace is assigned with the acquisition and processing geometry. The dataset is reduced to production-usable traces (i.e. trace edits applied).

NMO (normal moveout) stacking velocities associated with the conditioned data shall be provided.
The format for the conditioned data shall be SEGY. All geometry and complementary information shall be stored in the trace headers. Values (coordinates, times) shall be scaled so that a sufficient accuracy is maintained by the integers used in the trace headers (e.g. scale static corrections to 10*ms).

The format for the NMO velocities may be anything suitable that provides the velocity/time picksets. It may be a tabular format per text file, e.g. SEG P1.

This product has the purpose of making available a conditioned dataset suitable for NMO correction and CMP (common midpoint) stacking and, more generally, as a basic input for image processing.

The travel-time reference of these data is the NMO datum (typically a floating datum).

Geometry information shall be provided by trace headers and shall include:

- Shot/source ID, field record number, FFID
- Source point identification: line, point, index
- Source point position: easting, northing, ground elevation, shot hole or airgun depth
- Source type identification (if different types or configurations were used)
- Source uphole time
- Source static corrections (base and residual)
- Elevation of intermediate (pseudo) datum at source point
- Receiver point identification: line, point, index
- Receiver point position: easting, northing, ground elevation
- Receiver type identification (if different types or configurations were used)
- Receiver static corrections (base and residual)
- Elevation of intermediate (pseudo) datum at receiver point
- Per trace: source/receiver offset and azimuth
- Per CMP group: CDP, IL, XL numbers
- Per CMP group: bin center easting and northing coordinates
- Per CMP group: elevation at midpoint position
- Per CMP group: NMO floating datum elevation at CMP bin center
- Per CMP group: two-way travel time from NMO floating datum to reference datum (SRD)

The processing report shall describe:

- static correction (base and residual statics; underlying model and derivation of the base statics)
- signal processing
- denoise processing
- dynamic corrections (stacking velocities, NMO datum)

3.2.4 Final image(s)

This product shall contain one or more zero-offset seismic reflection images (i.e. migrated stacks or stacked pre-stack migrations). It must include one basic or universal image in the time domain, which shall be identified by the provider as primary image, in case more than one version is submitted.

The format of this product is SEGY. The time or depth reference shall be the final seismic reference datum (SRD).

The trace headers shall include:

- Time/depth sampling details (interval, trace length, time/depth of first sample)
- 2D seismic CDP or 3D-seismic IL/XL numbers
- Bin center coordinates
- Ground elevation at bin center
- NMO floating datum elevation at bin center
- Two-way travel time from NMO floating datum to reference datum (SRD)
- Information on phase (pref. zero phase) and polarity

The purpose of this product is to provide one or more ready-to-use seismic reflection images.

The processing reports shall:
- describe the processing and imaging workflow
- identify and characterize the image products
- include all resulting images, in case parallel processing is undertaken by the operator

3.3 File naming convention

Files must be named according to the following structure:

Project name <>2D or 3D<>year<>line or cube number<>short description<>numbering if necessary<>file extension

Example:

ProjectXY_2D_2024_line01_pre-mig_fullstack_001.sgy

The file name-length must not exceed 90 characters. Spaces between characters and special text characters must be avoided.

Only final files should be delivered.

3.4 Metadata

A list of metadata pertaining to the project and the survey must be provided in the appropriate spreadsheet (Annex A).
A map indicating the location of the survey (lines or area) should be included. Presuming that the project will involve GIS, the map must be provided as .mxd or .qgz projects with the associated shapefiles or geopackages of all relevant data (seismic sections, well locations, AOI polygons etc), georeferenced images and symbology.

3.5 Format

3.5.1 SEGY format proposal

Seismic data files should be provided in SEGY format. A description of the SEGY technical standard can be found at SEG's Technical Standards webpage (https://library.seg.org/seg-technical-standards).

3.5.2 File headers

A SEGY file shall contain the standard 3200-byte textual file header and the 400-byte binary file header. The optional tape header and optional extended textual file headers should be omitted.

3.5.3 Textual file header content

The textual file header should provide information, which clarifies/identifies (sorted by descending relevance):

- elevation of the reference datum
- time/depth domain
- assignment of relevant trace headers
- survey area
- data/product type
- date of acquisition and processing
- grid definition
- coordinate references systems (see Chapter 5)
- operating company
- data acquisition/processing service provider
- Impulse signal polarity
- Information on phase (pref. zero phase)
-

3.5.4 Data and trace header format

The trace-data format should be 32-bit floating point (either IEEE or IBM) only, i.e. no integer format. All trace-header variables shall be either 16- or 32-bit integer format (per SEGY technical standard), but not floating-point format.

3.5.5 Trace header assignment

Below is a proposed list for the assignment of the SEGY trace headers as outlined in the above sections. Most variables follow the standard SEGY header assignments. Variables marked by an asterisk (*) indicate complementary information for which non-standard positions are proposed or deviate from the SEGY standard.

The SEGY technical standard allows the storage of complementary information in the trace headers. The list below shall be considered as minimum required information and shall not be understood to exclude further/complementary information.

Trace header bytes	Content	A	B	S
1-4	Sequential trace number within data set	r	r	r
35-36	Trace use flag (0/1)	r	r	r
115-116	Trace length [number of samples]	r	r	r
117-118	Time [us] or depth [mm] sampling interval	r	r	r
21-24	2D or 3D CDP/CMP/CIP number	r2	r2	r2
189-192	3D inline number	r3	r3	r3
193-196	3D crossline number	r3	r3	r3
181-184	CMP/CIP bin center easting	r	r	r
185-188	CMP/CIP bin center northing	r	r	r
69-70	Elevation scaling factor to [m]	r	r	r
71-72	X/Y coordinate scaling factor to [m]	r	r	r
——–	——————————————-	—	—	—
215-218*	Ground elevation at CMP/CDP bin center	o	r	o
219-222*	Floating datum (FD) elev. at CMP bin center	o	r	o
223-226*	Two-way time SRD to FD at CMP bin center	o	r	o
——–	——————————————-	—	—	—
9-12	Original/unique field record number (FFID)	r	r	-
13-16	Original trace number within a field record	r	r	-
29-30	Trace ID code (see SEGY def)	r	-	-
133-134	Source type and/or configuration	r	o	-
139-140	Receiver type and/or configuration	r	o	-
17-20	Source point ID: line/point/index	r	r	-
73-76	Source station easting	r	r	-
77-80	Source station northing	r	r	-
45-48	Source station ground elevation	r	r	-
49-52	Source depth below ground elevation	r	r	-
95-96	Source uphole time	r	-	-
25-28*	Receiver station ID: line/point/index	r	r	-
81-84	Receiver station easting	r	r	-
85-88	Receiver station northing	r	r	-
41-44	Receiver station ground elevation	r	r	-
37-40	Source/receiver offset	r	r	-
113-114	Stack mute end time (time after NMO)	-	o	-
227-230*	First arrival time pick	r	o	-
99-100	Source station statics (base+residual)	o	r	-
101-102	Receiver station statics (base+residual)	o	r	-
157-158	Source time stamp: year	r	o	-
159-160	Source time stamp: day of year	r	o	-

Trace header bytes	Content	A	B	S
161-162	Source time stamp: hour	r	o	-
163-164	Source time stamp: minute	r	o	-
165-166	Source time stamp: second	r	o	-

where
A = Prepared/merged field data
B = Conditioned pre-stack data
S = Zero-offset volumes, stacked image or data traces
o = optional
r = required
r2 = required for 2D data
r3 = required for 3D data
- = undefined, not applicable

Source and receiver station IDs, which for 3D data typically consist of line, point and index numbers, may be coded into a single trace header per source or receiver using a composite number such as LLLLPPPPI, where L are digits providing the line number, PPPP are digits providing the point number and I provides the index.

4 Development phase

The subsurface development phase, as defined in the relevant ordinances, encompasses drilling into a previously characterized reservoir for geothermal energy production, as well as a possible reinjection well and monitoring wells.

Wells drilled in either phase, prospection or subsurface development, are to be reported in the same way, as described below.

4.1 Data to be delivered

At the end of the subsurface development phase, all related data are to be delivered to swisstopo.

The data to be delivered includes:

- Raw and processed data (for example well logging, mud logging, VSP, hydraulic/pressure tests data and results, fluid lab analysis, …)
- Graphical representations of the data (field prints, composite plots, logs…)
- Reports describing how data has been acquired/processed by the service companies (reports describing the operations, end of well report, end of section reports, daily/weekly/monthly reports)
- Data interpretation (geological report, test results interpretation, 3D models, etc.).
- Miscellaneous project related data and reports (for example seismic monitoring by project owner, environmental monitoring)
- Metadata for integration in the boreholes.swissgeol.ch web application, a borehole data management system
- Physical data (samples, cuttings, thin sections, cores, etc.)

4.2 Data structure

Data must be delivered in a folder with the following structure:

Main Folder (Well name)	Sub-folders (Datasets)
WellboreXY-1	01 WL
	02 MWD
	03 LWD
	04 Well path
	05 Mud logging
	06 Cores
	07 Cuttings
	08 Fluids
	09 Pressure tests
	10 DST-Hydro-Prod tests
	11 VSP
	12 Composite logs
	13 Geology
	14 Petrophysics
	15 Well doc
	16 Miscellaneous

In case of sidetracks or multilaterals, a separate folder will be created for each track.

Annex B gives a detailed description of the above-listed datasets, associated technical specifications and format requirements. This annex should be filled before (planned data acquisition) and after the drilling and logging operations (actual data acquisition).

Each project is different and it is the responsibility of the project owner to decide on the methods and data to be acquired in line with the project's objectives. Therefore, some of the listed

dataset entries may remain empty if the corresponding data acquisition was not planned and/or not performed.

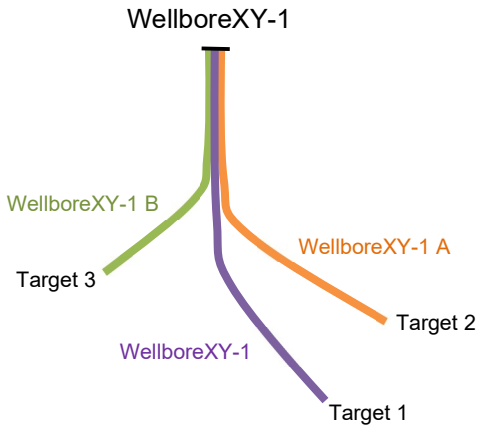
For a summary of the tools and their application in geothermal wells, please refer to the document “Recommendations for data acquisition in the frame of geothermal exploration drilling”, elaborated by Geothermie Allianz Bayern / Technische Univesität München in the frame of the Geothermie Schweiz Program Transfer.

Annex C “Subsurface development data inventory” must submitted by the operator and contain the following information:

- The “Section Overview” sheet allows to understand how the well has been drilled and completed (as built design)
- The “Logging Overview” sheet sums up all well-logging operations completed in the well
- The “Data” sheet is the inventory list of all files delivered to swisstopo
- The “Metadata” sheet compiles a set of basic information for the borehole database
- The list of cuttings describes and documents the cutting samples transferred to swisstopo and/or to cantonal core shed facility
- The list of cores describes and documents the cores transferred to swisstopo and/or cantonal core storage facility

4.3 Well naming convention

General name of the well:	WellboreXY-1
Name of the first wellbore:	WellboreXY-1
Name of the first sidetrack:	WellboreXY-1 A
Name of the second sidetrack:	WellboreXY-1 B



4.4 File naming convention

Well log files must be named with the following structure:

Wellbore name <> Bit-size <> Run number <> Tool(s) type <> Data <> Field or Processed <> Main, Repeat or both <> file extension

Example of a raw data-log file:

WellboreXY-1_8.1-2in_Run4.3_ DSL_ UXPL_XMAC_ All_Curves_Field_Main-Repeat.dlis

To reduce the number of possible tool string permutations in the file name, the generic tool names in tool strings may be listed alphabetically. Also, since AUX and GR are always part of the tool strings, these may also be omitted, thereby shortening the tool strings. Under these rules, the tool string e.g. GR-RES-DEN-NEU-SON-AUX should be rendered DEN-NEU-RES-SON.

Well reports must be named with following structure:

Wellbore name <> short description <> file extension

Example of a report file:

WellboreXY-1_mudlog_report.pdf

The file-name length must not exceed 90 characters. Spaces between characters and special text characters must be avoided.

4.5 Metadata

A list of metadata pertaining to the project and the well(s) must be provided in the appropriate spreadsheet (Annex C).

4.6 Format

The data formats are defined in Annex B.

4.7 Reference for the measurement of depth

The depth reference, e.g. rotary table drill-floor (DF) or rotary Kelly bushing (RKB), and its height above mean sea level (MSL) must be clearly defined by the project owner and are mandatory information.

All reported log data shall be in measured depth (MD) with respect to chosen reference level to be consistently maintained over the entire well. Additional plots in true vertical depth (TVD) may be delivered but must be identified as such.

5 Coordinate reference system

The delivered data should be referenced to the coordinate reference system CH1903+ /LV95 coordinate system (EPSG code: 2056). The transformation from WGS84 to CH1903+/LV95 shall follow the guidelines of swisstopo. The geodetic datum CH1903+ (ESRI SRID 21781) is described by the EPSG code 4150.

The elevation reference system shall be LN02 (NF02), with reference to Repère Pierre du Niton H (RPN) = 373.6 m in Geneva.

Transnational acquisition data may have more than one coordinate system. If this is the case, delivery shall include both CH1903+ and the foreign country’s system. This information must be contained in the file headers.

6 Data transfer

All primary, processed primary and secondary “interpreted” data must be delivered to swisstopo within the deadlines defined in Chapter 2.

Only the final versions of the data and reports should be supplied.

Data are transmitted via a transfer link if within the volume limits, or on a hard disk if the volume is too large.

Data delivery includes fully completed Annexes A, B and C (depending on the phase).

7 Data publication

According to the above-mentioned legislative acts, primary geodata and processed primary geodata from the prospection and development phases must be made available to the public.

Secondary geological data and information (interpreted data) will not be published, unless the project owner gives the permission to swisstopo to publish the data.

Seismic prospection datasets 1, 2, 3 and 4 and the metadata (see Chapter 2) will be made available to the public.

Well datasets to be published, whether from the prospection phase or the subsurface development phase, are indicated in Annex B, column “Publication”.

Documents that are intended to be published in accordance with these specifications must not contain cost information, copyright-protected content or indications such as “confidential” or similar. It is the responsibility of the project owner to inform the companies, sub-contractors and partners that data will be published.

8 References

Parts of the technical requirements have been taken and/or adapted from the following references, which are publicly available online.

- SEG Technical Standards
- Guidelines for reporting well data to authorities after completion (Blue Book), Version 14.0, 2022, Norwegian Petroleum Directorate
- Guidelines for reporting geophysical data to authorities (Yellow Book), Version 6.0, 2018, Norwegian Petroleum Directorate