Developing Criteria for Assessing The Stability of Water Supply Models in High Mountains and Water-Scare Areas

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Abstract

The article presents the scientific basis for assessing the stability of water supply models and develops a suitable set of criteria to assess the stability of water supply works, which includes the water supply part for water supply works and systems (including headworks and water distribution systems) in high mountains and water-scarce areas in Vietnam.

Research results indicate that in order to improve the stability and availability of water of the models that have been, are and will be built, it is necessary to have a common method of evaluating effectiveness for scientific models of domestic water supply. Accordingly, it is necessary to build obtain a suitable set of criteria to assess the stability of the water supply model (source + water supply works) in the high mountains, water-scarce areas in Vietnam.

Keywords: *criteria, water supply, high mountain, Vietnam*

1. Introduction

Domestic water is always an extremely valuable and urgent resource for human life, especially in the high mountains and water-scarce areas in Vietnam. Over the years, the State, people and international support organizations have focused a lot of investment resources on the field of domestic water supply. Vietnam has made great achievements in the field of rural water supply. Besides the achieved achievements, there are still limitations and shortcomings. The reality of domestic water supply models in high mountain areas and water-scarce areas in recent years has shown that many water supply models operate unstably and have low efficiency, which is assessed due to the influence of many causes. One of the basic reasons is the power supply and works system.

From the above situation, it is necessary to have a scientific assessment method of general effectiveness for domestic water supply models in order to improve the stability and water supply capacity of the models that have been, are being built and will be built. Accordingly, it is necessary to develop a suitable set of criteria to assess the stability of the water supply models (source + works) in the high mountains and water-scarce areas in Vietnam.

1.1. Objectives of the study

Develop criteria to evaluate the stability of the water supply models, including the part of the water supply for the works and the system of water supply works (main works and water distribution system) built in the high mountains, water-scarce areas.

1.2. Research contents

- Collect relevant documents;
- Research overview of solutions and current status of water supply models in high mountains and water-scarce areas in Vietnam;
- Research the scientific basis and propose appropriate criteria to assess the stability of the water supply model (source + works) in high mountainous areas and water-scarce areas.

1.3. Research Methods

- Collect documents on solutions and exploitation technologies of water supply models in high mountains and water-scarce areas in Vietnam.
- Synthesize and analyze solutions and exploitation technologies of water supply models based on collected documents. From there, develop criteria to evaluate the stability of the water supply model (source + works) in high mountains and water-scarce areas.

1.4. Research scope

The scope of the study is according to Decision 1553/QD-TTg dated November 8, 2019 of the Prime Minister approving the adjustment of the program to investigate and search for underground water sources to supply domestic water in high mountains and water-scarce areas in our country, including: Northern region of 15 provinces, North Central region of 5 provinces, South Central region of 7 provinces, Central Highlands region of 4 provinces, Southern region of 10 provinces.

1.5. Research subjects

Models of water supply (including supply source and supply works system) within the scope of the study in high mountains and water-scarce areas in Vietnam.

2. Water supply models in high mountains and water-scarce areas

- Model of water supply by hanging pond [1], [2];
- Model of water supply by the hill roof drainage moat

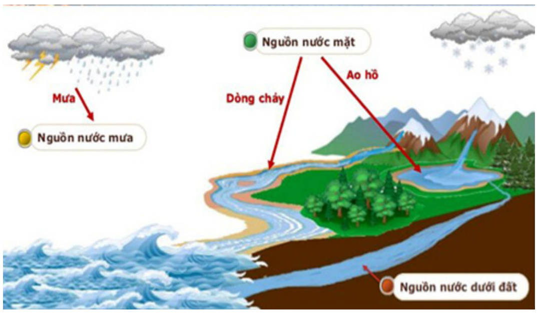

Fig. 4.1. Main types of water supply for the study area

Tab. 4.1. Assessment of the project's ability to meet water use demand

Level	Evaluation Criteria
A	Qpi ≥ Qyci and objects, the scale of water supply is expanded more than the design
B	Qpi ≥Qyci and objects, guaranteed water supply scale according to design
C	Qpi < Qyci and the object and scale of water supply are not met compared with the design

Tab. 4.2. Classification of surface water quality - Limit values of parameters and concentrations of components in each type of surface water [11]

No.	Parameters		Units	Types of surface water		
				Type A	Type B	Type C
1	pH			6.5 to 8.5	6.0 to 9.0	pH > 9 and pH < 6
2	Turbidity		NTU	< 20	< 500	< 1.000
3	Colour degree		mg/l Pt	< 10	< 100	< 200
4	Oxidation KMnO4		mg/l O2	< 2,0	2 – 5	< 10
5	Total hardness		°dH	4 - 8	< 4 or 8 - 13	< 28
6	Sulfide	H_2S	mg/l	0	0	< 0.5
7	Chloride	Cl^-	mg/l	< 25	< 200	< 400
8	Sunfates	SO_4^{2-}	mg/l	< 25	< 250	< 400
9	Nitrites	NO_2^-	mg/l	< 0.1	< 1	< 2
10	Nitrates	NO_3^-	mg/l N	0	< 6	< 10
11	Photphate	PO_4^{3-}	mg/l	0	< 1,5	< 2
12	Total iron	Fe	mg/l	< 0.3	< 1	< 2
13	Total Manganese	Mn	mg/l	< 0.2	< 0.5	< 1
14	Amonium	NH4+	mg/l	< 0.2	< 0.5	< 1
15	Fluoride	F-	mg/l	0.5 – 1.0	< 1.5	< 2
16	Xianua	CN-	µg/l	0	< 50	< 100
17	Phenol		µg/l	0	0,5	< 100
18	Arsenic	As	µg/l	0	50	< 100
19	Cadmium	Cd	µg/l	0	< 1	< 5
20	Total chromium	Cr	µg/l	0	< 10	< 50
21	Selenium	Se	µg/l	0	< 5	< 10
22	Mercury	Hg	µg/l	0	0	< 1
23	Copper	Cu	µg/l	< 50	< 1.000	< 3.000
24	Lead	Pb	µg/l	0	< 10	< 50
25	Zinc	Zn	µg/l	< 50	< 1.000	< 5.000
26	E.Coli		MPN/100 ml	< 20	< 100	< 200
27	Total pesticides (except DDT)		mg/l	0	< 0,15	< 0,15
28	DDT		Bq/l	0	< 0,01	< 0,01
29	Total radioactivity α		Bg/l	< 0.1	< 0.1	< 0.1
30	Total radioactivity β		Bg/l	< 1	< 1	< 1

system using the BTC1 water collection tape [3];
- Model of water supply by underground dam system on stream using BTC1 water collection tape [3];
- Model of water supply by horizontal wells [4];
- Model of water supply by jet well [4];
- Model of water supply by underground dams to block and slow down the flow to create underground lakes to raise the groundwater level for water supply [5];
- Model of water supply by exploiting surface water of streams;
- Model of water supply by taking water from the hillside exposed circuit by collecting tank;
- Model of water supply by taking water from the popular open source from limestone;
- Model of water supply by dug well;
- Model of water supply by single borehole [7];
- Model of water supply by the well corridor;
- Model of water supply by rainwater tank from the roof;
- Model of water supply by exploiting open-circuit karst water source using water collection tape [7];
- Model of water supply by collecting open source water using retaining wall technology combined with water collection tape [8];
- Model of water supply by collecting open source water using distributed water collection tape technology [8];
- Model of water supply by applying underground dam technology integrating technology of collecting wells, foothill water storage and horizontal river bottom groundwater collection system [9].

3. Scientific basis for developing criteria for assessing the stability of water supply models

3.1. Based on the documents and dossiers on design and construction of water supply works

Documents in the phases of construction survey and construction design of the works.

Documents in the construction phase of the works.

3.2. Based on the data of inspection and assessment of the current status of water supply works

Tab. 4.3. Classification of groundwater quality - Limit values of parameters and concentrations of components in each type of groundwater [11]

No	Parameters		Units	Type of groundwater		
				Type A	Type B	Type C
1	pH			6.8 – 7.5	6.0 – 8.0	4.5 – 8.5
2	Oxidation KMnO4		mg/l O_2	< 0.5	0.5 – 2.0	< 10
3	Total hardness		°dH	4 - 8	< 4 or 8 - 13	< 28
4	Sulfide	H_2S	mg/l	0	0	< 0.5
5	Chloride	Cl-	mg/l	< 25	< 200	< 400
6	Sulfates	SO4--	mg/l	< 25	< 250	< 400
7	Nitrites	NO2-	mg/l	< 0	< 0,1	< 2
8	Nitrates	NO3-	mg/l N	0	< 6	< 10
9	Photphate	PO4---	mg/l	0	< 1.5	< 2
10	Total iron	Fe	mg/l	< 0.3	< 10	< 50
11	Total Manganese	Mn	mg/l	< 0.05	< 2	< 3
12	Amonium	NH4+	mg/l	< 0	< 3	< 30
13	Fluoride	F-	mg/l	0.5 đến 1.0	0 – 0.5 or 1.0 – 1.5	< 2
14	Xianua	CN-	μg/l	0	< 50	< 100
15	Phenol		μg/l	0	0,5	< 100
16	Arsenic	As	μg/l	0	50	< 100
17	Cadmium	Cd	μg/l	0	< 1	< 5
18	Total chromium	Cr	μg/l	0	< 10	< 50
19	Selenium	Se	μg/l	0	< 5	< 10
20	Mercury	Hg	μg/l	0	0	< 1
21	Copper	Cu	μg/l	< 50	< 1.000	< 3.000
22	Lead	Pb	μg/l	0	< 10	< 50
23	Zinc	Zn	μg/l	< 50	< 1.000	< 5.000
24	E.Coli		MPN/100 ml	< 0	< 20	< 100

Tab. 4.4. Summary of criteria for assessing the stability of water supply source

Degree of assessment	Rating conditions
1	When the water supply capacity of the source to the works according to the design requirements and the water quality meeting the requirements for domestic use reaches "Level A".
2	When one of the following conditions is met: Current quality reaches "Level A", the water supply capacity according to the design reaches "Level A" and status of water source reaches "Level B"; or Current quality reaches "Level B", the water supply capacity according to the design reaches "Level A" and status of water source reaches s "Level A"; or Current quality reaches "Level B", the water supply capacity according to the design reaches "Level A" and status of water source reaches "Level B".
3	When the water supply capacity of the source to the works according to the design requirements reaches "Level B" and the quality of the water source meeting the requirements for domestic use reaches "Level A", or The quality of the water supply reaches "Level A", the water supply capacity according to the design reaches "Level B" and the status of water source reaches "Level B"; or The quality of the water supply reaches "Level B", the water supply capacity according to the design reaches "Level A" and the status of water source reaches "Level A"; or The quality of the water supply reaches "Level B", the water supply capacity according to the design reaches "Level A" and the status of water source reaches "Level B".
4	When the water supply capacity according to the design reaches "Level C" or the water quality of the supply source reaches "Level C"

- Inspection of water supply works

Inspecting concrete and reinforced concrete structures of focal works

Checking water transfer works

Checking sedimentation, fill of water supply works

Checking the operating system

- Assessment of the current status and causes of instability of water supply works

Works of surface water exploitation

Works of mainstream water exploitation

Works of underground water exploitation

- Standards and regulations for the assessment of the stability of the works
- Standards and regulations for the assessment of stability of water supply systems

3.3. Proposal to develop criteria for assessing the stability of the water supply models

Based on the above-mentioned practices and scientific bases, it is proposed to develop criteria to evaluate the stability of domestic water supply works in high mountains and water-scarce areas as follows:

- For water supply:

+ Criteria to meet the demand for water use

+ Criteria to meet water quality

- For water supply works:

+ Criteria for assessing the current state of the works

+ Criteria for assessing permeability stability

+ Criteria for assessing the stability of the structure of the works

+ Criteria for assessing the sedimentation before the construction

4. Developing criteria for assessing the stability of water supply models (source + works) in high mountains and water-scarce areas

4.1. Criteria for assessing the stability of water supply source

Domestic water supply for high mountains and water-scarce areas is mainly in 3 main forms:

- Surface water: water that is directly visible, exists mainly in rivers, streams, lakes or man-made dams.
- Groundwater source: a form of groundwater, is fresh water contained in the pores of soil or rock. It can be interconnected pockets of water or a geyser that flows close to the parent rock. Groundwater is formed by water on the surface seeping down, because it cannot penetrate

Tab. 4.5. Contents of quality inspection of water supply works

Items	Contents of quality inspection
Structure made of concrete, reinforced concrete, stone masonry	Check the condition of cracking, cavitation, pitting, rusting (if any) of concrete structures, masonry; Check deformation, displacement of the works through the expansion or difference at the joints; Check the condition of seepage, water leakage through the water conduit items, through the pipe joints; Check the sandy soil deposited in the water source; Check for erosion; Check the degree of damage, the operability of mechanical equipment. Check the degree of damage, the operability of electrical equipment
Structure of gabion, stacked stone	Check deformation, displacement; Check the condition of peeling, slipping; Check the integrity of the gabion; Check the deposited sandy soil at the water intake; Check for erosion; Check the degree of damage, the operability of mechanical equipment. Check the degree of damage, the operability of electrical equipment

Tab. 4.6. Assess the current quality of the works

Levels	**Assessment conditions**
A	Equipment and items of the works are not damaged
B	The work is only damaged in unimportant structural parts (station buildings, reinforced structures of shore roofs, roads); can be repaired through maintenance work, annual maintenance
C	The work is seriously damaged, affecting the efficiency, and needs to be repaired or upgraded in time

the parent rock layer, so the water will concentrate on the surface. Depending on the geological tectonics, it forms different shapes, water concentrated much will start to move and link with other water compartments and pockets, gradually forming large and small groundwater. The exploitation of groundwater can be through forms such as dug wells, drilled wells, jet wells, etc.

- Rainwater source: water generated by condensation of water vapor. This is also a fairly popular source of domestic water for people in high mountains and water-scarce areas through the construction of storage tanks, catchment roofs, rainwater collection pits, etc.

The stability of water supply of an operating or exploiting domestic water supply work is assessed through two groups of criteria: (1) Ability to meet the demand for water use and (2) Ability to meet the demand for water quality.

4.1.1. Criteria of ability to meet the demand for water use

Assessment of the ability to meet the demand for water use is one of the criteria for assessing the stability of supply source of water supply models. To evaluate this criterion, it is necessary to calculate specifically the incoming flow and water demand, water balance. From that, calculate the benefits that the work brings.

Thus, the ability to meet the demand for water use is assessed through two factors: (1) The water source is represented by the incoming flow rate corresponding to the frequency of service assurance (applicable to the surface water source); (2) Demand for water use.

- Water source

To determine the water source to the work, calculate the yearly flow rate to the work according to the design frequency Qp and the design yearly flow distribution Qpi (where i is the order of the month of the year and P is the frequency of the design).

- Demand for water use

+ Identify water users

The water users of the work may have one or many different objects, including: supply of domestic water to households and agencies;

+ Demand for water use

The demand for water use is determined according to the following formula:

$$Q_{yci} = \frac{Q_{nni} + Q_{shi} + Q_{khi}}{\eta} \qquad (4.1)$$

in which:

Q_{yci}: The required volume of water supply at the head of the works in the i month, m³/s;

Q_{nni}: The required volume of water supply for agriculture in the field in the i month, m³/s;

Q_{shi}: The required volume of water supply for domestic use in the household in i month, m³/s;

Q_{khi}: Required volume of water supply for other economic sectors in the i month, m³/s;

η: Canal utilization coefficient.

+ Determine the demand of water supply for domestic use

Water demand for domestic use includes water demand for people in urban or rural areas and water demand for livestock (cattle, pigs, ...), poultry.

The required volume of water supply for domestic use in the i month is determined by the formula:

$$Q_{shi} = Q_{ngi} + Q_{chni} \qquad (4.2)$$

in which: Q_{shi}: The required volume of water supply for domestic use in the household using water in the i month, m³/s;

i = 1 ÷ 12: Order of month of the year;

Q_{ngi}: The required volume of water supply for the households using water in the i month, m³/s;

$$Q_{ngi} = \frac{10^{-3}.q_{ng}.N_{ng}.D_i}{86400} \qquad (4.3)$$

q_{ng}: Norm of water supply for people in water-using households, l/person/day and night, determined according to current regulations;

Tab. 4.7. Table of criteria for assessing permeability stability of water supply works

Degree of permeability stability	Assessment Criteria
A	When all of the following conditions are satisfied: - Total seepage is less than or equal to total water loss due to infiltration according to design calculation; - The maximum permeability gradient at local points (J_{cbmax}) is smaller than the allowable gradient value ($[J_k]_{cp}$): $J_{cbmax} \leq [J_k]_{cp}$; The calculated mean permeation gradient (J_{tt}) is less than the mean critical gradient of the water column (J_k^{tb}) taking into account the reliability coefficient (K_n): $J_{tt} \leq (J_k^{tb}/K_n)$; - The seepage pressure and backlash pressure are less than or equal to the design value (for hanging tigers, tanks, concrete dams, reinforced concrete and casting constructions); - Parameters of water drainage equipment ensure technical requirements.
B	When one of the following situations occurs: - The total amount of seepage is greater than the total amount of water loss due to infiltration according to the design calculation; - There is at least one maximum permeability gradient value at local points (J_{cbmax}) equal to the allowable gradient value (($[J_k]_{cp}$) or the calculated average permeability Gradient value (J_{tt}) equal to the critical gradient value average of the water column (J_k^{tb}) taking into account the reliability factor (K_n); - The seepage pressure and backlash pressure are higher than the design value, but the dam and the casting works still ensure the sliding stability in the calculated cases as prescribed.
C	When one of the following situations occurs: - There is at least one maximum permeability gradient value at local points (J_{cbmax}) greater than the allowable gradient value (($[J_k]_{cp}$) or the calculated average permeability Gradient value (J_{tt}) greater than the gradient value mean water column criticality (J_k^{tb}) taking into account the reliability factor (K_n); - Infiltration pressure, backlash pressure increase suddenly, abnormally, higher than the design value for dams and casting works which are likely to lose stability; - The parameters of the drainage device do not meet the technical requirements.

Tab. 4.8. Table of criteria for assessing structural stability of water supply works

Structural stability degree	Assessment Criteria
A	When all of the following conditions are satisfied: a) For weirs made of earth and rock: - The displacement of the dam is less than the allowable value; - The dam is stable. b) For weirs made of concrete and reinforced concrete: - Dams are not subsided, horizontal displacement; - Stabilized dam sliding, flipping; - Dam foundation and dam body concrete have sufficient bearing capacity. c) For hanging lakes - The structure of the lakeside roof, the lake bottom is stable without slipping - No cracks or cracks with the width within the allowable range - The lake is not subsided or displaced - The lake bottom ensures bearing capacity d) For collection well works (ray well, drilled well, dug well) - The wall of the well does not sink - No cracks in the well wall or cracks with the width within the allowable range c) For related works: - Sliding and overturning stabilization works; - The foundation of the items ensures force-resistance capability.
B	When one of the following occurs: - For weirs made of earth and rock: The dam roof has been unstable and has been repaired; The existing dam roof ensures stability. - For weirs made of concrete and reinforced concrete: The dam is subsided and the transverse displacement is within the allowable limit; - For hanging lakes and open water collection ponds: The roof has been unstable and has been repaired; The current roof of the building is stable. The foundation of the work is subsided but within the allowable limit. - For related works: Parts of works sliding, tipping and foundation of the items ensure force-resistance capability.
C	When one of the following occurs: a) For weirs made of earth and rock: - Dam has subsidence, displacement is greater than the allowable value; - The dam roof is unstable. b) For weirs made of concrete and reinforced concrete: - Subsidence, displacement of the dam body is larger than the allowable value; - The dam does not guarantee sliding or tipping stability; - Dam foundation and dam body concrete do not guarantee force-resistance capacity. c) For hanging lakes - Subsidence, displacement of roof and foundation is greater than the allowable value; - The roof is not stable; - The work foundation and concrete structure do not guarantee the force-resistance capacity. c) For related works: - Work parts that do not guarantee sliding stability or tipping stability; - The foundation does not guarantee force-resistance capacity.

N_{ng}: Number of people using water;
D_i: Number of days of the ith month;
Q_{chni}: Required volume of water supply for livestock in the household using water in month i, m³/s;

$$Q_{chni} = \frac{D_i}{86400} . \sum_{j}^{n} 10^{-3}. \quad (4.4)$$

q_{chnj}: Norm of water supply for a jth cattle or poultry in a water-using household, determined according to current regulations depending on the type of livestock and poultry (cattle, pigs, poultry);
N_{chnj}: The number of the jth livestock and poultry using water;
n: Total number of livestock and poultry supplied with water.

- Assess the ability to meet the demand for water use

Assess the ability to meet the water use demand of water supply works according to 03 levels:
Level A - Satisfying water demand well;
Level B - Meeting the demand for water;
Level C - Does not meet the demand for water.

Tab. 4.9. Assessment of sedimentation in front of the dam

Levels	Assessment conditions
A	$K_t \geq [K]$ và $K_l \geq [K]$
B	$1,0 \leq K_t < [K]$ và $K_l \geq [K]$ hoặc $1,0 \leq K_l < [K]$ và $K_t \geq [K]$
C	Either coefficient K_t or K_l is less than 1.0

Tab. 4.10. Summary of criteria for assessing stability of water supply works

Levels of rating stability	Ranking conditions
1	All criteria in item 0 reach "A" level
2	All of the criteria in item 0 are rated "A" and "B"
3	The other cases

4.1.2. Criteria for the ability to meet the quality of the supply water source

The quality criteria of supply water sources for domestic use in high mountains and water-scarce areas are assessed through limit indicators and concentrations of substances present in water (determined through sampling and analysis of water samples in the lab).

- For surface water sources: TCXD 233-99 provides quality criteria used to compare, evaluate and select raw surface water sources when researching and preparing pre-feasibility reports and feasibility reports on investment and construction projects of domestic water supply as follows:
- For underground water source: TCXD 233-99 provides the quality criteria used to compare, evaluate and select groundwater sources when researching and preparing pre-feasibility reports and feasibility reports on investment and construction projects of domestic water supply as follows:

Tab. 4.3. in which:

Column A: is a water source of good quality, which is simply treated before being supplied for drinking and domestic use;

Column B: is a water source of normal quality, which can be exploited and treated for drinking and domestic use;

Column C: is a water source of bad quality. If used for the purpose of supplying drinking water and domestic use, it should be treated with special technologies and must be strictly and regularly monitored for water quality;

4.1.3. Summary of criteria for assessing the stability of supply source

Tab. 4.4. in which:

Level 1: The water supply source for the model (works) is very stable, meeting well the conditions of domestic water supply

Level 2: The water supply source for the model (works) is stable, meeting the conditions of domestic water supply

Level 3: The water supply source for the model (works) is less stable

Level 4: The water supply source for the model (works) is not stable

4.2. Criteria for assessing the stability of the works

4.2.1. Criteria for assessing the current state of the works

Assessing the current state of the proposed work is one of the important bases for assessing the stability of the works. It is based on the assessment of current status and measurement and monitoring data to assess the stability of the works according to current standards and regulations.

Assess the current quality of the works according to the following levels:

Level A: Good quality;

Level B: Medium quality;

Grade C: Poor quality.

The current quality of the works is assessed according to Table 4.6

4.2.2. Criteria for assessing permeability stability

4.2.3. Criteria for assessing structural stability

4.2.4. Criteria for assessing sedimentation in front of the construction

The sediment deposited in front of the weir can cause sedimentation to narrow the inlet size leading to a decrease in the discharge capacity of the inlet and more importantly, an increase in sediment pressure along with other possible loads and destabilize the dam.

Assess the level of sedimentation in front of the dam according to the following levels:

Level A: Sedimentation of sand does not cause unsafety for the weir;

Level B: Sedimentation of sand may cause unsafety for the weir; need to strengthen supervision.

Level C: Sedimentation of sand is unsafe for the dam, it is necessary to dredge the sand before the dam.

The sedimentation status of the sediment in front of the dam is assessed according to Table 4.9. Assessment of sedimentation in front of the dam.

In which:

K_t, K_l respectively are the safety coefficients of slip stability and tipping stability of the weir, taking into account the effect of sediment pressure in front of the dam, [K] is the allowable stability coefficient.

4.2.5. Summary of criteria for assessing the stability of the works

Tab. 4.10. i n which:

Level 1: Water supply works are stable

Level 2: Water supply works are unstable, must strengthen inspection and supervision

Level 3: Water supply works are unstable, potentially unsafe; need to be checked, repaired and upgraded immediately.

5. Conclusion

- The stability of (source + works) domestic water supply in water-scarce areas depends on natural conditions, topography, geology, construction materials, management level, exploitation and operation as well as the perception of water users. This report has proposed a set of criteria to assess the stability of water sources and water supply works for domestic water supply models for the study area.

- The report has presented quite fully the types of water supply models, which are divided into 2 main types: Surface water exploitation model (surge dam, underground dam, hanging lake, highway ...) and groundwater exploitation model (types of wells).
- The report also stated the scientific basis for assessing the stability of the water supply models. The important basis are: (1) The system of documents for survey, design, exploitation and operation... of the work; (2) Survey, evaluation and monitoring of the current status of the works and (3) System of standards and regulations as a basis for assessment.

From that, develop a set of criteria to evaluate the stability of the water supply models for high mountains and water-scarce areas in Vietnam as follows:

For sources:

+ Criteria to meet the demand for water use

+ Criteria to meet the requirements of water quality of the supply source

For the works:

+ Criteria for assessing the current state of the works

+ Criteria for assessing permeability stability

+ Criteria for assessing structural stability

+ Criteria for assessment of sedimentation in front of the construction

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