Rehabilitation of ThongChon, Popdong and Chonnae Water Supply Systems (Kangwon Province, DPR of Korea)

Hydrogeological and Hydrological Survey

Mission Report
June 2002

SUMMARY
The mission of the expert hydrogeologist took place in DPRK between March 21st and May 23rd. The mission was finalised to support the rehabilitation of the WSS of the towns of Thongchon Popdong and Chonnae plus some villages (co-operative farms "Up" and "Upnongjangni") and the rehabilitation of the Antiepidemic Centres of the counties of the same towns, in the Kangwon province.

The work was carried out in the CESVI office in Pyong Yang, but mostly in the target counties by means of seven missions in the field.

The aims of these missions were the following:

- Preparation of a list of the equipment, laboratory glasses set and reagents necessary for the Antiepidemic Centres.

- Evaluation of the degree of safety of the WSS sources as well as of the potential of both ground and surface water sources. In the course of the survey measurements of pH, electrical conductivity and temperature were taken on sources water samples.

- Acquisition of topographic data (head, length) on the lay-out of the pipelines to rehabilitate; training of the province and counties WSS technical personnel on the utilisation of the Total Topographic Station supplied by the project.

The project intervention areas are located toward the eastern coast, in Kangwon province (capital Wonsan), close to the sea (Thongchon), at the foot of hills, seaward (Chonnae) or in the middle of deep valleys (Popdong).
- The first (Thongchon) is a town in equilibrium between agriculture, fishery and industrial activity.
- The second (Chonnae) is an industrial city, also characterised by mining activity.
- The third (Popdong) is an agricultural town.

All the anti-epidemic centres of the three counties are presently in a very poor state, since most of the equipment is obsolete or broken or useless for the lack of reagents. The technical personnel seems motivated and (in the average) capable to perform both biological and chemical analyses.
The project did not foresee equipping the centres both for biological analyses and chemical determinations because modern equipment (spectrophotometers) is very expensive. Since biological pollution in DPRK is estimated more probable than chemical, priority was given to the equipment to perform such analyses; in the meanwhile the centres will be supplied with reagents and lab-glasses useful for traditional chemical determinations. The following analyses were suggested as priorities:

- Ammonia
- Nitrites
- Nitrates
- Chlorine
- Phosphates

The safety of the water sources was mainly evaluated in a qualitative way, since pH, Ec and temperature are parameters that may give normal values even in the presence of biological or (some) chemical contamination.

Anyway the measured parameters resulted well inside the normal (or so considered) range. Definitive results will be obtained only when the anti-epidemic centres will be properly working.
In a general way the problem of a possible pollution doesn't seem to affect the target sources both for their position (upstream of settlements, industries, sheds and grazing areas) and for the absence (or the scarce utilisation) of fertilisers in the country. From another point of view, it is to be underlined that DPRK population is by far accustomed to boil water before drinking and this constitutes anyway a further security. Very likely pollution could be a worse problem in wide flat areas of intense industrialisation or intensive cattle breeding (as an example along the Tae Dong River downstream of Pyong Yang).

On the water quantity subject, most of the source visited has yields agreeable for the foreseen supplies.

- In Thongchon (shallow well in alluvial plain) it was verified that with 3 irrigation wells, each pumping about 100 l/sec, in a ray of few hundred metres, the dynamic water level was less than 10 cm lower than few days before, with no active wells around.

- In Chonnae the source is a karstic spring that, at the end of the winter dry season, didn't give any water drop during pumping.

- In Popdong the source (a stream) had an about double yield in comparison to the town necessity, at the end of the dry season.

Concerns are limited to a couple of villages around Popdong, but unfortunately there are not alternative available sources.
About catchments, the project is going to rehabilitate most of the streams and springs catchment in Popdong County and a couple of shallow wells in Chonnae farm. In Chonnae town few interventions have been suggested to avoid the possibility of external water running into the cave during rains. In Popdong it has been suggested to shift a catchment from the actual position (in a stream) to about 150 m upstream, where some water is springing directly from coarse deposits. In few others cases it has been proposed the construction of a catchment buried in the riverbed to avoid damages by the stream erosion.

The topographic survey, carried out with the help (and the direct participation) of the provincial responsible for the WSS, has been very useful to define the exact length and head of the towns (and of the main farms) pipelines.

- In Thongchon the new transmission layout was some hundreds metres shorter of the county responsible forecasts.
- In Chonnae a similar difference was found and the head was reduced from 50 to 30 m.
- In Popdong about 700 m of pipeline had been calculated in excess and the head was found about 20 m wider.

At the end of the surveys maps and topographic profiles have been drawn for each study area. They are enclosed to this report.
On the basis of this activity more suitable designs of the pipelines and a different materials purchase plan have been realised.

All these activities were performed with the full support of CESVI expatriate and local staff, with the cooperation of the FDRC province and counties authorities and with the willingness of the province and counties WSS officers. The skill and the care that technical personnel put in the project goals realisation have been a basic condition for the successful result.

1. REHABILITATION OF ANTI-EPIDEMIC CENTRES

As anticipated in the summary the situation found during the visits to the centres was really worrying.

In all of them the equipment were broken or obsolete or the centres activity was strongly limited for the lack of laboratory glasses and reagents. After the first series of meeting with the centres technical and administrative personnel, the idea to supply each of the centres with a portable kit (both for chemical and biological determination) was discussed with the project responsible. The advantages of such a choice could have been the possibility of both determinations, an easier laboratory activity (avoiding problems of professional skill) and a faster purchase order. At the end we thought that the personnel had enough skill and enthusiasm to carry on a full activity in the laboratories. Furthermore the portable kit has the drawback to afford a limited number of analyses, after which new kits of disks and reagents have to be supplied with high costs and difficulties. A traditional rehabilitation helps the centres because of an easier supply of reagents and it develops more the professional skills.

At this point the attention was focussed on the priorities of the requested equipment. The project budget didn't

afford the purchase of spectrophotometers and at the same time of the equipment for biological analysis. The priority was given to the latter and a list of devices and reagents was prepared on the basis of each centres requirement. The proposal was re-discussed with the centres personnel, modified and by them approved.

Another problem was how to improve the possibilities of movement and (water samples) transport by the centres personnel, since presently they move by means of occasional lifts. The possible choice was between bicycles and motorcycles. Because of the country fuel shortage the priority was given to the former hypothesis unless the personnel declared the fuel availability (at Chonnae).

2. WATER SOURCES

In Kangwon province the watershed dividing basins bringing water to the Yellow Sea (westward) from those discharging in the Korean Sea (eastward) runs very close to the coast. This means that courses in the eastern coastal area are very short and with steep slopes. They have a stream character and the alluvial deposits are coarse (mainly pebbles, gravel and sand). This fact means that alluvial aquifers usually have high potentials and also shallow wells may give high yields.

Limestones (mainly in Chonnae province) constitute the second important aquifer when subject to karstic phenomena. The water circulating in karstic conducts find an impervious obstacle in the crystalline intrusion that constitutes a continuous, parallel to the coast, sub-vertical sort of dam. Very likely this is the reason for the karstic springs of the area and for their high yields.

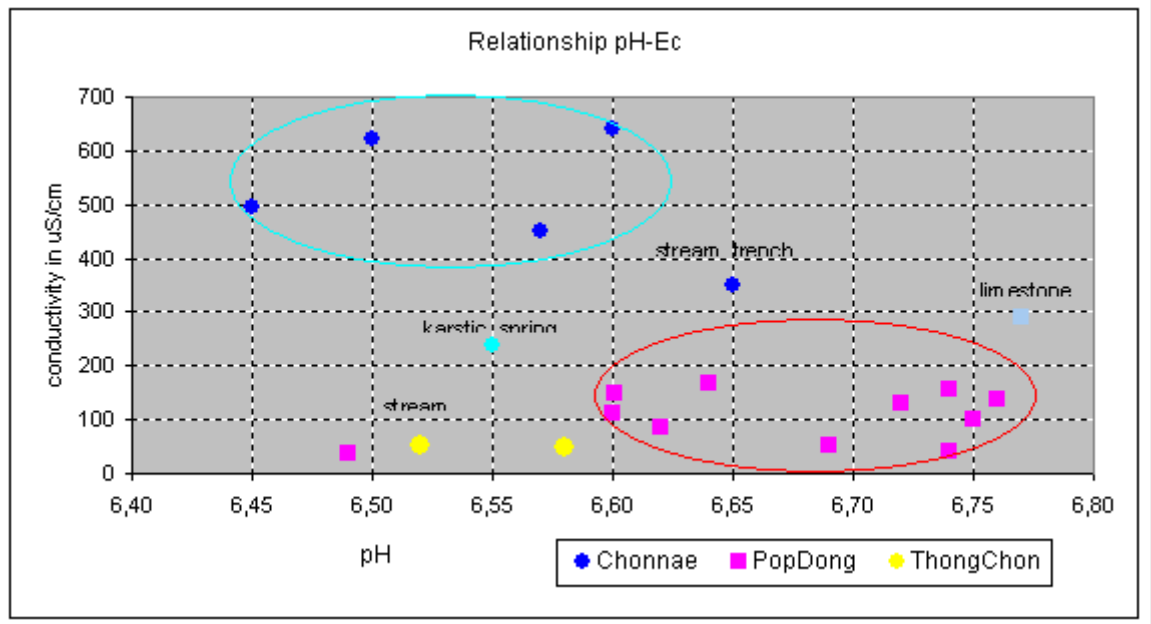
The third group of sources, in Popdong province, is constituted by small streams usually fed by springs coming from coarse flank (or morainic) deposits or from granite fractures.

Each of these groups can be characterised by different ranges of conductivity, temperature and pH, as shown in the table1. Graphic relationships are shown in fig.1

county	WSS	source	pH	Ec (iS/cm)	T
Chonnae	Farm1	shallow well	6,57	450	12,4
	Farm2	shallow well	6,45	500	12,4
	Farm3	shallow well	6,60	640	11,0
	Farm4	shallow well	6,50	620	12,4
	Town1	karstic spring	6,55	240	12,5
	Town2	stream trench	6,65	350	
Thongchon	stream	stream	6,52	53	17,0
	irrigation well	shallow well	6,58	48	12,2
	Town1	shallow well	6,58	49	12,8
Popdong	Town1	stream	6,49	38	9,0
	Town2a	stream	6,76	136	13,0
	Town2b	spring	6,72	130	8,0
	Town3	borehole	6,60	150	18,0
	Town4	stream	6,75	100	13,0
	Farm1	stream	6,74	41	12,0
	Farm2	stream	6,69	52	14,8
	Farm3	stream *	6,62	87	8,9
	Farm4	spring *	6,64	169	11,0
	Farm5	spring *	6,60	110	10,5
	Farm6	stream	6,74	157	12,7
	Farm7	stream	6,77	289	11,8

Tab. 1

*: measured while raining



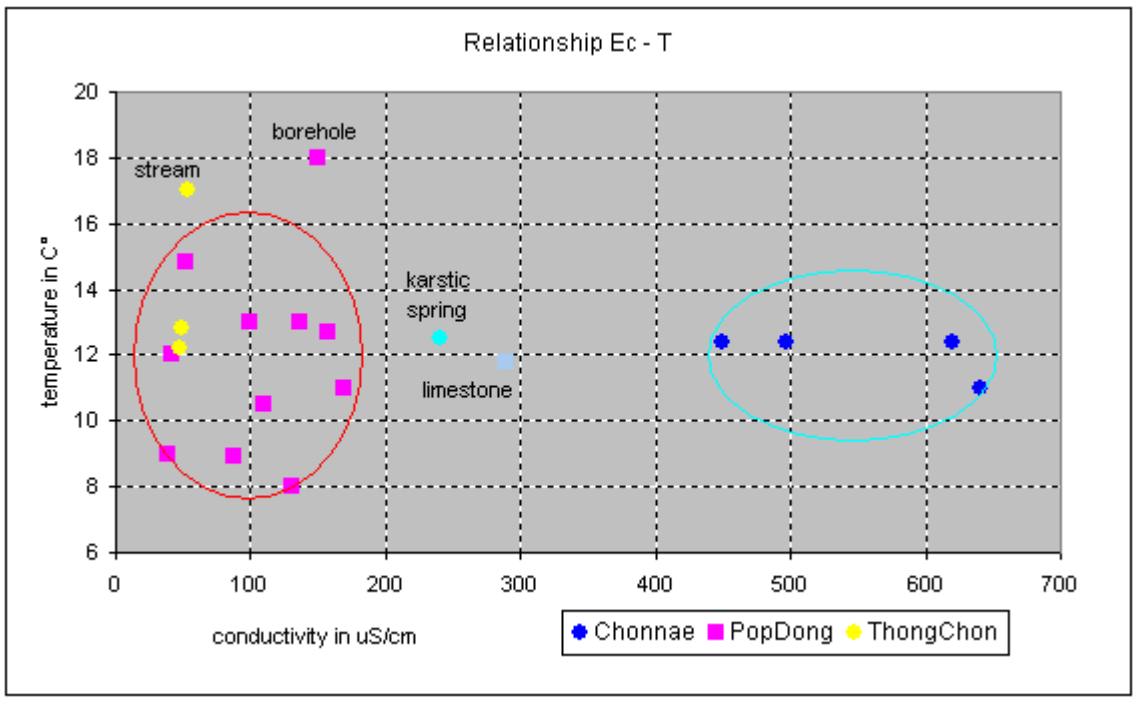


fig. 1

From the table and the graph it is clear that most of the data are inside two big groups:

- The wider one is constituted by the Popdong sources (streams) and ThongChon wells; there conductivity values are homogeneous (between 40 and 170 ìS/cm) while pH and T data are widespread, mainly for different meteorological conditions at the time of the measurement. The low Ec values are related to the crystalline basement outcropping behind Popdong and in the basin of the Thongchon stream. As a matter of fact, crystalline rocks (in the area granite prevails) release less ions than sedimentary rocks. The only anomalous value of conductivity (289 ìS/cm) is coming from a stream in a limestone hydrogeological catchment (on the opposite site of the Rimjin River). Higher temperature values have been measured on a sample taken from the water springing from the only borehole visited.

- The smaller group is related to Chonnae shallow wells; the conductivity values are much higher (450-650 ìS/cm) while the pH is lower. Both conditions are very likely due to the calcareous basin and to the underground circulation (pH and T are very similar to those of Thongchon shallow wells). From the graph it results clearly the different conductivity of the karstic spring, not so different from that of the Popdong Farm n.7, that is probably a stream with a karstic alimentation. The values of pH and Ec measured on the water of the second Chonnae

source (stream trench) are intermediate between the two groups, since the basin of the stream is mainly characterised by granite outcrops.

From the point of view of the yields, it has not been possible to carry out pumping tests on the groundwater sources both for the shortage of time and for the variability of the electricity supply times. Some tries on Thongchon and Chonnae wells failed for the latter reason. Anyway some information has been given by the WSS attendants and from field observations.
On Popdong streams a rough evaluation was done but during different missions, some before rains (at the end of the dry season), other after first rains, some while raining. Because of this the yield values cannot be compared.

In the following chapters a detailed description of the sources and of the WSS characteristics is given.

3. WATER SUPPLY SYSTEMS

3.1 THONGCHON WSS

3.1.1 Geological and Morphological Framework

Thongchon is a town of about 23.000 inhabitants located on the coast of Korean Sea. The town extends, at the foot of a basaltic hill on the NW side of a plain about 3 km wide and 2-3 km deep inland. Other basaltic hills constitute the arms of the town northern gulf. The plain very likely is made by deposits of an ancient marine lagoon mixed with alluvial sediments. From the morphology and the information, finer deposits (lagoon) prevail on the NW side (the town side), while the coarser (alluvial) prevail on the SE side of the plain. In the latter part two streams joint making an alluvial fan mainly constituted by coarse gravel; the topographic surface decreases slightly from the fan toward the town. The basin of the stream is mainly made by crystalline rocks. It is to underline that the town is subject to sporadic tidal waves (or tsunami) and this phenomenon could give a fair salt content in the soil, in the north-western sector of the plain. The fact is to be taken in account when planning the pipes material.

3.1.2 The Source

The water source of the town is located in the alluvial fan area, about 500 m NW of the stream and about 70-90 m east of the railway. The source is a shallow well, hand excavated and outside concrete finished and covered. The well has a circular section with a ray of about 4 m, a depth of 5.3 m (in average) from the topsoil. On the coverage top there is a smaller concrete cylinder with a manhole.

In the underground part, coarse gravel and small boulders, very likely taken in site, make the walls. At the moment of the first inspection (on the 2nd of April '02) the water level was at 4.40 m from the top of the manhole, about 2.4 m from the topsoil. The pumps had been worked up to two hours before. The pumps attendants referred that, with an exploitation yield estimated at 80 m3/h (about 22 l/sec), the water level usually drops of 20 cm and that it recovers very quickly after the end of the pumping. On the next two visits the dynamic water level, measured after 4 hours of pumping, was found at 4.23 and 4.32 m; the former value was taken during a strong rain. The second lower value was measured while 3 irrigation wells in a ray of few hundred metres (the nearest was 30 m beside) were exploited. The pumping was on already from 3-4 hours, with a yield between 50 and 100 l/sec. Very likely rains are the reason of the higher levels found in the last inspections.

From the information given by the attendants, when the pumps were new, the well was exploited by an yield of 180 m3/h (50 l/sec), with no higher water drops.

During each inspection the water was very clean and odourless. The state of the structure is fair. The closest irrigation well, about 30 m northward, is a dug well or better, just a large hole (about 50 m2) in the ground. Even there the water was clean and odourless.

Looking at materials (pebbles, coarse gravel), position (alluvial fan) information (previous exploitation yield) and the observed exploitation (contemporaneously by the WSS and the irrigation wells) the potential of the source is appropriate for the town supply. The yield of 240 m3/h (about 67 l/sec), that is the triple of the current, can be considered adequate to the well potential.

Around the well an area of about a hectare is limited by tree lines and the railway; in this area is not allowed the use of herbicides and fertiliser to preserve the water quality.

3.1.3 The WSS

Two centrifugal pumps of 180 m3/h each, constitute the exploitation mean. The pumps alimentation is a 220 V current modified by a 3.300 V industrial line of input transformer. Both pumps and transformer are very old and often subjected to break down. The pumps seem to be in a worse condition since the frequency of the breaks is

higher (the transformer has been told to break down once per year). The power of the motors of the pumps is 75 kW each.

The WSS was designed with a capacity of 180 m3/h to push the water along an about 3.000 m long pipeline (the new lay out is about 2.700 m long) up to a tank of 1.000 m3, on the hill close to the town. The main tank is about 47 m higher of the lowest part of the line; a secondary smaller tank is downstream, about 50 m far and 10 m lower (see map 1 and fig. 2). The first design turned out to have underestimated the total head losses so that the pumps were never able to send the water up to the tank. To reach the goal two buster pumps had to be located at the foot of the hill. The buster pumps too work (one at time) with a 220 V current, produced by a transformer similar to the one of the centrifugal pumps, but with an optional 380 V output.

The power supply is given by a small hydroelectric plant, run by the town administration, plus a transformer that outputs the 3.300 V current. The electrical line supplies, in the following order, the buster pumps, a couple of factories and the centrifugal pumps, where the line ends. The power available at the pump house (end of the electrical line) is about 150-160 kW.

The current supply is characterised by a variation of the voltage between 3.200 and 3.300 V. In the average the current is supplied 6 hours/day in winter and 10 in summer, with a mean of three breaks per day: The 70% of them is known and pumps attendants are informed in advance.

Thongchon authorities expect an improvement due to a larger hydroelectric plant, under construction in the Anbyon county. The plant could be finalised during the next year; a further electrical power supply has been promised by Anbyon authorities.

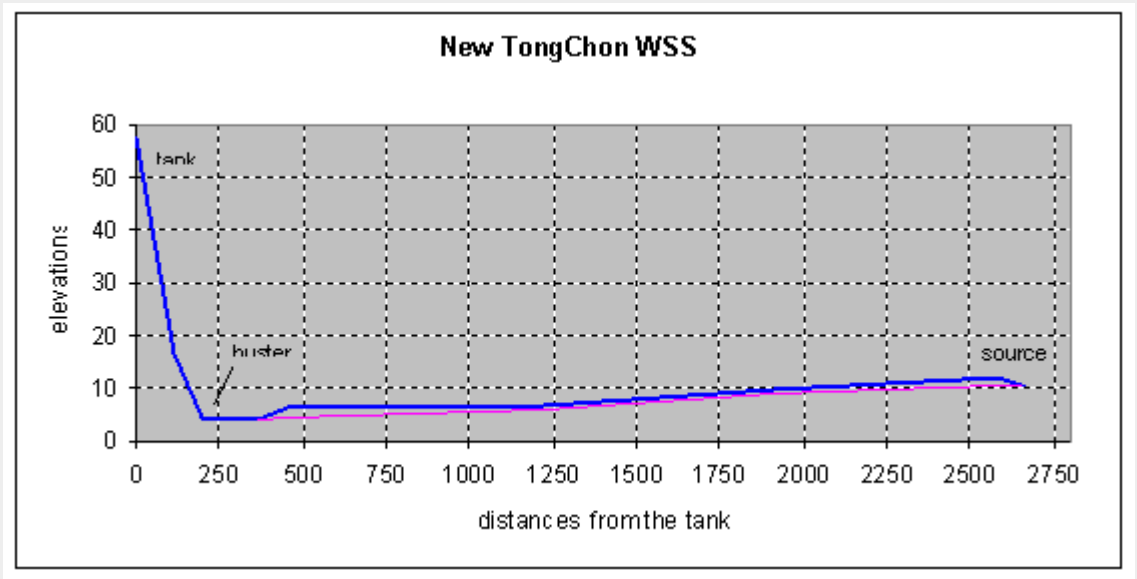


fig.2

3.2 CHONNAE

3.2.1 Morphological and Geological Framework

Chonnae is an industrial town of about 23.000 inhabitants located in a large valley on both banks of the river, about 10 km far from the sea. The old suburb and the main cement factory are located on the left bank, while the new part is on the other side of the river.

The old town is characterised mainly by low houses and narrows streets; it is divided in two parts by a limestone ridge on which top the water tank it is positioned. The new suburb is made by buildings and large roads; some factories and quarries are positioned, not far from the new suburb, on the right side of the main valley and in that of the main affluent.

In the main valley, as well as on the left side of the affluent, limestone hills constitutes the flanks, while, on the affluent right bank, granite outcrops up to about 1 km from the confluence. The alluvial deposits are coarse and mainly gravel. In the affluent valley, due to the gentler slopes of the basin and to the deep granite weathered layer, alluvial deposits are mostly sandy .

From the geological map of DPRK it can be seen that the granites constitute a very long intrusive body, NS

aligned, 5-15 km large, dividing inland calcareous deposits from the coastal ones.

The co-operative farm extends partly upstream of the old town and partly in front of it, on the opposite (right) river bank: in the upstream fraction about 1000 persons live, in the downstream one 320. Other fractions spread out more upstream, along the valley. The main suburbs are separated by a limestone ridge that protrudes from the hill flank up to the river bank. The largest fraction is located on a 1200 m long and 200 m wide plain and partly in a smaller lateral valley. The plain is about 5 m high on the riverbed. The composition of the alluvial deposits which constitute the plain is mainly gravel-sandy. Downstream suburb is located on the lower part of the hill flank.

3.2.2 Hydrogeological Pattern

From the hydrogeological point of view, limestones with karstic phenomena, constitute a rich aquifer of the area. Usually high infiltration and deep water circulation characterise the calcareous formations. The groundwater flow, directed from the core of the mountains seaward, finds a sort of underground dam in the intrusive body (granites), that causes the water rising and springing. This geological pattern can explain the karstic spring existing upstream of the old suburb of Chonnae, on the northern side of the limestone ridge. Very likely similar water emergences can be found north and southward of the town.

A second rich aquifer is constituted by the alluvial deposits (pebbles, gravel and coarse sand) that constitute the valley of the main river. These deposits are fed by the water of the river infiltrating upstream and by some underground water circulating in karstic conduct and fractures. Also the affluent stream, on the right side, makes a large valley in the confluence proximity, but the deposits size is mainly sandy and the thickness is probably thinner. Because of this their potential is lower.

3.2.3 The WSS

The spring that feeds the old town WSS is located in a cave in one of the deeper points of the valley where the northern suburb spread out. The water fills a pool in the deepest point of the cave and it seems to come through a karstic conduct, 4-5 m under the water level. An underground outflow (a larger fracture or another conduct) maintains the water level constant in the pool in dry periods; in the rainy (and intermediate) season the water level raises and the water runs away along a narrow, channelled drainage. The relationship between rains and variation of the karstic water flow is very important in a qualitative evaluation of the water quality, because, the longer the gap between rain and flow increase, the lower the possibility of contamination (longer underground courses). In the study case the relationship is not yet clear, since attendants told that the gap is very short, but it has been verified that a water raising (about 1 m) happened, at least, a week after the first springtime rain. It is recommended the installation of a graduated bar in the pool and of a rain-gauge in the city to start a constant action of measurements. From the point of view of the yields it was told by the pumps attendants that even in the dry season, the water level doesn't decrease during the pumping (presently about 20 l/sec, 50 in the past).

The chances of pollution of the source are very scarce, since upstream of the cave there are not further human settlements nor livestock grazing areas. All the possible sources of pollution (human and industrial) are downstream. If a delay of a week can be verified in the rain-water increase relationship, the source can be considered safe by possible contamination from far sites. The pH (measured on 11th of April) ranged between 6.54 and 6.56, while the conductivity was 240 S/cm and the temperature 14° C. The only possible contamination is from surface water which could run in the cave from the exterior, during strong rains.

The exploitation is realised by means of two pumps with a capacity of 180 m3/h. The pumps are very old and often need repairs. They works directly with a 3300 V electrical current since there is not transformer. The supply was told very irregular, usually varying between 2300 and 3000 V, during an average of 6 hours/day.

A topographic survey was carried out to check the length and the head of the transmission pipeline; a detailed survey of the cave was done too to make a detailed design of the interventions to dam the water run off from outside (see Encl. 2.1a, b and fig. 3). The survey done on the current pipeline found a total length a little more than 500 m and the head (between source and tank) a little less than 30 m. The lay out makes a sharp angle that cannot be avoided since there is a large construction with concrete floor on the straight route.

For the water safety in the cave it was suggested the construction of a little wall to deviate a possible external water flow toward the drainage downstream of the spring. The coverage of the section of the cave floor closest to the spring will be completed with concrete and the old barrages along the drainage have to be reshaped as shown in the Encl. 2.1b or partly destroyed.

The second water source, that feeds the WSS of the new part of the town, is located in the valley of the affluent stream, on the right bank. The source is constituted by a screened pipe buried about 1-2 m under the riverbed. The pipe brings water in a large tank by gravity. The pump house is just behind to the tank.

This catchment is not very agreeable for the high possibility of bacteriological pollution. In fact, the valley extends

far upstream, where many human settlements, livestock grazing and rice fields can be found. The thickness of sandy deposits covering the pipe is very thin (1-2 m) and it doesn't give enough guarantees as a filter against contamination. The water in the tank seemed a little bit less clear of the other source and odourless; pH and Ec, measured on sample carried up to Wonsan, were of 6.65 and 350 S/m. Temperature was not indicative after transportation.

Since the tank is very far from the source (2.5 km) and the pipeline runs under an old (but active) cement factory, the research of a new source is suggested as a necessary improvement, before any future intervention on the whole WSS. The possibility of finding a new source, more agreeable for quantity, quality and distance from the tank, seems to be high in the alluvial plain where the wells of the co-operative farm are located. A possible quick intervention can be suggested with the excavation of a trench beside the course, upstream of the pump house. The presence of underground water, even if probable, has not been verified during the visit, as well as the possible exploitable yield. Anyway it is not foresaw any intervention on this WSS.

Two wells feed the two main sectors of the farm WSS. The wells are both in the plain but very far from each other. On both pipelines a topographic survey was carried out to check lay out, length and differences in elevation between source, tank and farthest points of the lines. The results are in Encl. 2.2 and fig. 3.

The first well, upstream, is the source of the larger (and most populated) sector of the farm. This well has a square section of 3 x 3 m2. The depth is 6.0 m and the water level was measured at 5.1 m. The well is about 50 m from the river and the water level was found the same of the river during the topographic survey. This fact means that, very likely, groundwater can feed or to be fed by the river, according to the seasons. The water in the well is very clean and odourless. The pH was 6.57, electric conductivity 450 S/m and temperature about 12.4° C.

The second well is downstream of the first one, few metres from the foot of the limestone ridge which separates the farm fractions. It is a circular well wit a concrete coverage and an inner ray of 1.2 m in the first metre of depth. The section gets narrower at depth and the bottom profile is very irregular since it reaches the rocky bedrock. The maximum depth from the ground level has been measured at 3.8 m while the water (static) level was at 3.3 m. This level seems higher of the water in the river. The farm responsible and the county WSS responsible told that the water comes out from a fracture in the calcareous basement and that there is not any perceptible water level change during exploitation. The water in the well is very clean and odourless. The pH was 6.45, electric conductivity 500 S/m and temperature about 12.4° C.

Each WSS is run by a pump of 40 m3/h fed by 220 V electrical line. Both systems presently work at about a quarter of their capacity (10 m3/h) on 6 h/day. The power supply is discontinuous and the voltage much lower of the nominal value.

Since both pipelines feed a common part of the farm, but with very tortuous courses, better fitting layouts were discussed and accepted by the county authorities, on the basis of the survey results.

Two more wells were visited in a farther upstream fraction of the farm. These well are presently manually exploited by means of buckets. Both wells seem to drain alluvial deposits in a large bight of the river. The first one (numbered farm 3 in table 1) drains also very shallow water, since the level (1.1 m of depth from the concrete protection edge) was the same of the water filling the close rice field. Village inhabitants told that the water level drops very close to the bottom (4.4 m) in the dry season. The last well is few hundreds metres away from the previous, more inside the village. Here the water level was much lower (4 m from the ground level) while total depth was 5.3 m. People said that there is very little water in dry season. For these wells was proposed a rehabilitation covering and casing them with concrete up to 3-4 m of depth. A manhole will be left on the top and hand pumps will be supplied and installed.

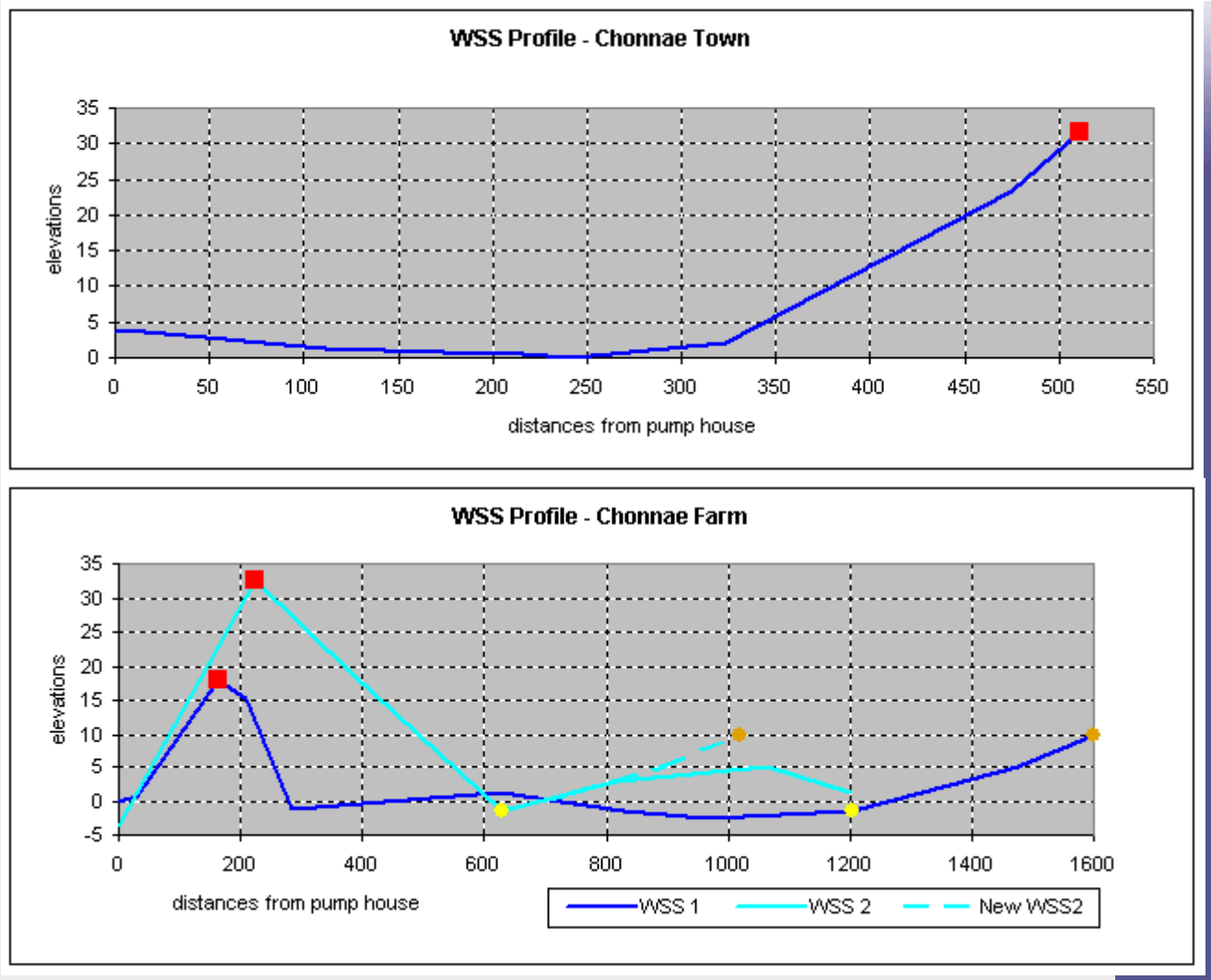


fig. 3

3.3 POPDONG WSS

3.3.1 Morphological, Geological and Hydrogeological Framework

Popdong is a town with 8900 people, located in the valley of Rimjin river, on its right bank, at an elevation of 260-280 m a.s.l.. The valley is very steep with limestones, sandstones and shales outcropping upstream and in front of the town (left side of the valley). Downstream and behind the town, on the right side, granites outcrop. Very likely the valley follows the pattern of a geological fault.

Four water source feed the town WSS and seven sources feed the same number of farm fractions; they are mainly constituted by small streams, few by springs, coming out of deposits covering the rocky basements or of fractures in the granitic basement. All water points (except one) are on the right flank of the valley. A sketch of the Popdong (town and farms) WSS has been drawn in Encl. 3.1.

3.3.2 Town WSS

The layout of pipelines (WSS) 1 and 2 are in Encl. 3.2. The altimetrical profiles are shown in fig 4.

The main source (S1) is constituted by a catchment, in a stream affluent of the Rimjin Gang, about 1.5 km upstream from the junction point. The affluent valley crosses the main road about two km southward. The catchment is at an elevation of about 400 m a.s.l.. In this point the water still runs on outcropping granite with slopes not less than 10%. The site (as well as the water) is clean and, upstream, the flank of the valley is covered by trees and bushes. There are not further settlement, nor factories or greasing areas. The spring has been told farther than 1 km away. The measured pH was 6.49, the conductivity 38 S/cm and the temperature 12.6° C. The minimum yield of the stream is told to be 35 l/sec, that was not far from the yield, estimated during the survey, in April, at the end of a very dry winter.

The existing catchment is a concrete box on a secondary branch. It will be replaced by a small concrete dam, 15-20 m upstream and 4-6 m large, that will divert the water into a small channel with a filtering function. The pipeline will start from a concrete small tank, at the channel end.

The pipeline length, measured by a topographic survey, was less than 2500 m (previous evaluation 3200 m); through several variations in elevation, the pipe arrives to the foot of an hill on which top is located a 150 m3 tank, 40-50 m higher of the town main plain. The total head between source and tank is about 110 m.

This source is the most important of the town. About 6.000 persons will be served by this system, while presently the upstream suburbs gets little water (or nothing at all).

The second source (S2) is located in another lateral valley, which crosses the main road about 1 km southward. The existing is a very small catchment in a very narrow and steeply cut stream, at an elevation of 325 m a.s.l.. The course cuts coarse, but with abundant fine matrix, deposits which constitute an intermediate terrace. The site was considered not very safe, because of animal excrements, clearly visible; furthermore the current velocity is very low (0.1-0.2 m/sec) as well as the yield (3-4 l/sec). Very likely in the rainy season, the course can mobilise a big amount of the fine deposits so that water can became very muddy. During the visit, anyway, the water was clear; the measured pH 6.76, the conductivity 136 S/cm and temperature 13°.

For safety reasons, it has been proposed to the WSS and FDRC authorities to shift the catchment 150-200 upstream, at an elevation of 360 m, where the water springs from the ground in several points, few metres aside of the stream course (at the site about dry). After the visit, the excavation of a transverse trench in the springing area has been proposed, so that water can be drained before any possible contamination. Since the total head between the new position and the town is more than 120 m, the WSS responsible suggested the construction of an intermediate tank to reduce water pressure. The total length of the new pipeline has been estimated at about 1300 m. At the spring site the measured pH was 6.72, conductivity 130 S/cm and the temperature 8°. The existing system serves about 750 persons in the southern part of the town.

The third source (S3) is not far from the main source (S1), in a small valley affluent of the course of the S1 stream. It is constituted by a borehole, drilled in the past for mineral research, in which water rising over the ground surface was found. The borehole seems to have a depth of 30-40 m, but true depth, diameter and yield is unknown because the top of the pipe is closed in a concrete box without manhole. A 300 m long and highly leaking pipe brings the water up to a town fraction of about 700 persons. The head between the source and the end of the transmission pipe is estimated at about 50 m. The catchment will be re-built with access for inspection. The following parameters were measured on a water sample taken at the outlet of the catchment: pH = 6.60, Ec = 150 S/cm and T = 18°. It is to underline the anomalous value of the temperature, higher because of the deeper water circulation.

The fourth source (S4) is located in a lateral valley of the stream Byongam that cuts the town centre. The lateral drainage is about 1 km upstream from the bridge of the main road. The source is made by a concrete catchment in the middle of the course. The water runs between large blocks and it looks very clean for the absence of fine matrix in the deposits. Downstream of the catchment the drainage is steep (about 30°). Authorities asked for the rebuilding of the catchment, but not for the pipes substitution (at least for the main transmission pipe). The measured pH was 6.75, the conductivity 100 S/cm and the temperature 13°.

3.3.3 Farm WSS

The co-operative farm of Popdong is constituted by several villages; in seven of these it has been planned an intervention. To avoid confusion each village will be indicated with the same number with which have been named the sources. These numbers have not any relationship with the villages position. The rough position of sources and villages is sketched in Encl. 3.1. The villages from 1 to 6 are on the right side of the valley, the seventh on the left. All the distances, indicated as distances from the town, have been roughly measured (by car odometer) from the square with the obelisk, located at the town entrance, coming from north along the main road.

- Village n.1

The first village of the co-operative farm is 3.6 km southward from Popdong, and it is constituted by two main settlements. The upper part of the village is located about 200 m above the road at the foot of an hill. The lower settlement is located about 500 m under the road, not far of the Rimjin river. Presently only the upper hamlet receive water from a poor source (not visited); the water has not enough head to reach the higher houses of the settlement. The whole village population is about 350 persons; only 100 are presently served by the WSS. The village authorities, together with the county responsible, proposed the catchment of a new source. This is constituted by a stream running in a small valley, on its left flank, on outcropping granite. The water is very clean, its pH is 6.74, the Ec is 41 S/cm and T is 12°; the total yield was estimated at 20 l/sec. There are not grazing

areas or settlements upstream. The catchment will be done by a little dam which will convey the water in a concrete tank aside of it. The length of the new pipeline from the source to the lower part of the village is estimated at 1250 m, the partial head to upper village at 30 m, while the total (up to the lower hamlet) is about 100 m.

- Village n.2

The second village of the co-operative farm is about 1.8 km southward from Popdong, about 1 km far from the main road. It is located on the river bank, about 200 m from the riverbed and 4-6 m higher. The village (300 inhabitants) rehabilitated the WSS last year with recycled PVC pipes. The poor quality of the material makes the leakage very high. The source is the same stream caught by the source S1 of Popdong town. The catchment, about 2 km far from the town square, is made by a little stone dam with a screened pipe buried under stones. The measured parameters are: pH = 6.69, Ec = 52 S/cm and T = 14.8°; the total yield was estimated at 50 l/sec. This source is the most unsafe of all those visited. It is few hundred metres downstream of the suburb served by the source S3 of the town and it is unprotected against bacteriological pollution. Furthermore, village authorities said that in dry season almost all the water is taken away by the town WSS and that their WSS gets dry. They asked for the pipes substitution and, if possible for a new catchment. Since the catchment is located only few hundred metres down the town WSS 3 (that fed by the borehole) and the source seems to have a more than satisfactory yield for the suburb, it has been proposed to county authorities to extend the town WSS 3 up to the village, to insure a safer water supply. The proposal was accepted and it will be discussed with village authorities. A 1500 m long pipe was roughly estimated to connect the village. Since the head from the source it is more than 100 m, it is very likely enough for the water to rise the hill that divides the village from the road and the stream (the current catchment), shortening in this way the pipeline lay out (see Encl. 3.1).

- Village n.3

The third village of the co-operative farm is along a rural road that starts about 2200 m northward (upstream) from Popdong. The settlement is scattered in several groups of houses, only partly along the rural road, on an alluvial plain made by an affluent stream. Total population is at 300 persons, only 60 presently served by the pipeline. The source is in a lateral drainage in a small stream, that cuts deposits made by boulders and blocks. The water parameters, measured while raining, are: pH = 6.62, Ec = 87 S/cm and T = 8.9°; the total yield was estimated at 5 l/sec but it was told that in dry season there is very little water. Evidences of strong erosion are visible and the catchment was destroyed little time ago by floods. Now it is substituted by a box made by planks. The pipes are made by recycled and highly leaking PVC. The proposed new catchment will be an underground trench, to preserve it from erosion damages. To serve the whole population authorities required 1550 m of pipes (400 from the source to the foot of the hill, the others to connect the settlements). The main line head is estimated at 40 m.

- Village n.4

This village is located not far from the previous, about 2600 m from the town, upstream. Total population is 300 persons, of whom only a 50% is connected to WSS. The source is about 2000 m far from the road and it is constituted by a circular, by stones built catchment, at the foot of an alluvial fan made by coarse materials. The water springs at the foot of the excavation and it is collected by a pipe at the downstream edge of the catchment. The parameters (measured during a rain) have the following values: pH = 6.64, Ec = 169 S/cm and T = 11°; the total yield was estimated at 2-3 l/sec. It is to underline the higher conductivity and temperature values, probably due to the underground circulation. The new proposed catchment will be a kind of shallow well, buried but accessible trough manhole, with the pipe exiting underground (about at 1.5 m of depth). The village asked for 1500 m of pipes (500 with 60 diameter for the main line). The head of the main line is estimated at 20 m. From the end of it the village spread only at lower elevations.

- Village n.5

The fifth village is located at the upstream town edge, about 850 m from the square, 200 m far from the road at the hill foot. The population is 200 inhabitants, only 25% served by the WSS. The source is a spring coming out of deposits on the flank of the hill, about 30-40 m higher of the alluvial plain of the village. The catchment is a concrete box buried in the ground and not accessible, so that it is not possible to evaluate the yield. The parameters (measured while raining) have the following values: pH = 6.60, Ec = 110 S/cm and T = 10.5°. The village asked for 650 m of pipes (150 with 60 diameter for the main line), but not for the catchment rehabilitation.

- Village n.6

Village n. 6 spread out in front of the fifth, on the riverside of the road. The total number of inhabitants is around 700, but there is a little uncertainty about it. There were not yet available data on the served population percentage. The source is a very poor stream, with a small made by sand dam and a pipe. The water fall down

along a wall of intensely fractured schists. The yield was very poor and it was estimated at 1.0-1.5 l/sec; the survey was carried out before rains. The parameters measurement gave the following values: pH = 6.74, Ec = 157 S/cm and T = 12.7°. The catchment will be substituted with a new one in concrete. At the end of the mission it was not yet known the length of the pipes to rehabilitate the WSS but from a rough estimation it could be about 1000 m.

- Village n.7

The last village visited is on the left side of the valley and it is reachable by means of a rural road that crosses village 6 and the river by means of a ford. The village spreads out from the mouth of a large lateral valley up to the foot of the hills of the Rimjin river valley. It is constituted by many small settlements and the distance between the source and the furthest hamlet is more than 2000 m. Total population is 600 persons, only 380 receiving water at alternate days, for the high leakage of the pipes. The source is a stream on the right side of the lateral valley, not far from the mouth on the Rimjin Valley. The catchment is not far from a limestone wall. Several water points coming out from coarse deposits (at the wall foot) have been checked upstream, but villagers told that they dry up in the dry season. In the area the stream presents evidences of strong erosion. In one point, in the last autumn, the water opened a new cut (2-3 m deep) in the deposits, damaging the pipeline. The yield was estimated at 2-3 l/sec but could be higher considering the water circulating in the shallower part of the subsoil. The values of the water parameters are the following: pH = 6.77, Ec = 289 S/cm and T = 11.8°. The catchment is made by a 20 cm high cement dam with a screened pipe fixed inside of it. The new one will be larger and higher but it is recommended a mainly underground work to protect it by the erosion. The WSS rehabilitation looks difficult for the low head (a rough estimation is of 20 m between the source and the end of the main pipe, 800 m requested with a 100 mm diameter) and for the little head between this point and the farthest part of the village (1300 m). A more detailed survey (at least on distances) could help a more accurate design.

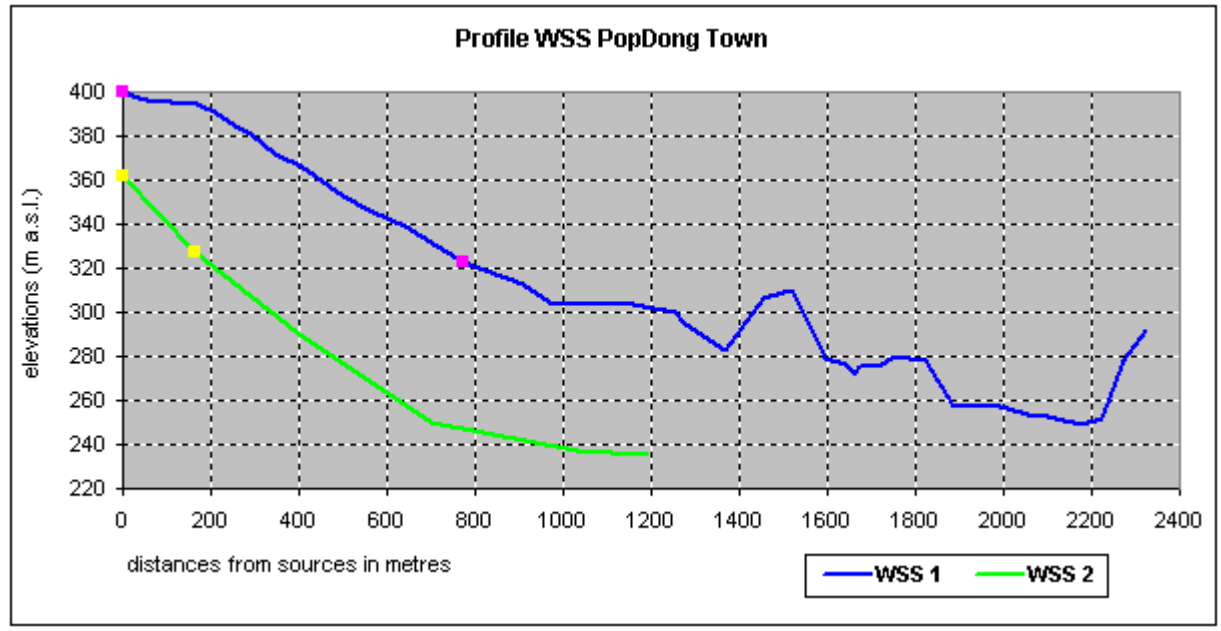


fig. 4

See all maps for this Emergency
By Emergency:
- DPR Korea

By Country:
- Democratic People's Republic of Korea (the)

By Source:
- CESVI - Cooperazione e Sviluppo Onlus (CESVI)

By Type:

- Situation Reports

FIND RELATED DOCUMENTS

By Emergency: DPR Korea
By Country: Democratic People's Republic of Korea (the)
By Source: CESVI - Cooperazione e Sviluppo Onlus (CESVI)
By Type: Situation Reports