# Reconstruction Support in the Tohoku Region

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**Abstract**

**At the time of the Great East Japan Earthquake (the "Quake") on March 11, 2011, great damage occurred to city water purification plants and Wastewater Treatment Plant (WWTP) facilities. We were in charge of restoration work of electrical facilities at these WWTP facilities, and delivered and installed electrical equipment there. The initial recovery work featured an installation of a temporary electrical facility first, and then restoration work of the damaged facilities occurred in phases. In addition, simplified remote monitoring system using mobile phone network was employed to reduce operation control burden during the restoration period.**

**After the Quake, in the field of water purification, we arranged a high-voltage mobile power generating system in the Yonai Water Purification Center, Morioka City, Iwate Prefecture. As a result, stable operation of water purification was possible even during the power outage.**

## 1 Preface

When the Great East Japan Earthquake (the "Quake") took place on March 11, 2011, multiple-city Water Purification Plants (WPPs) and Wastewater Treatment Plant (WWTP) facilities were severely damaged by the big earthquakes and tsunami. The WWTP facilities for which we installed electrical equipment were also critically damaged. This paper introduces the conditions at the Kennan Water Purification Center (WPC), Ofunato WPC, and the Kesennuma WWTP from the time of the Quake damages to restoration. Our work after the Quake at the WPP facilities is also introduced.

## 2 Kennan WPC

### 2.1 Outline of the Facilities and Situation of Disaster

The Kennan WPC is a river basin WWTP site located at the mouth of the Abukuma River, Miyagi Prefecture, on the Pacific coast. The daily maximum processing capability is 125,000m$^3$/d and a conventional system of activated sludge process is adopted.

Damages in the electrical facilities were caused by submersion by tsunami. There was no serious damage in equipment installed on the second and upper floors. Table 1 shows the condition of the installations belonging to the major system.

**Table 1** Major Facilities at the Kennan WPC

Damages of electrical facilities were caused by submersion attributed to the tsunami. Equipment installed in the first and lower floors of the respective facilities was severely damaged.

| Facility name | Major facilities | |
|---|---|---|
| | Installed in the first and lower floors | Installed in the second floor and above |
| Administration building | | Electricity room, monitor room |
| In-house power plant building | Electricity room, generator room | |
| Grit chamber pump room | Electricity room, pump main body | |
| Primary dehydrator building | | Electricity room, dehydrator main body |
| Secondary dehydrator building | Electricity room, monitor room | Dehydrator main body |
| Fuel facilities | | Electricity room |
| Mechanical thickener building | Thickener main body | Electricity room |
| Blower building | Blower main body | Electricity room |
| Primary water treatment | Electricity room | |
| Secondary water treatment | Electricity room | |
| Sand filtration building | Electricity room | |
| Chlorine sterilization building | Electricity room | |
| Digestion gas & boiler building | Electricity room | |

## 2.2 Recovery Situation

In order to control wastewater overflow from manholes, temporary submergible pumps were used to discharge wastewater to the river. Until the recovery of power feeding from the power company, the power source had been was secured from a temporary power generating system. After the restoration of the utility system, the temporary incoming substation facility was installed. Fig. 1 shows the temporary outdoor incoming substation facility. In this manner, the function of wastewater pumping-up was assured. For the improvement of effluent water quality, a temporary sedimentation tank was installed inside the WPC so that we could secure the process from settling to sterilization.

In the meantime, the main pumps were recovered to start regular operation. With the aid of temporary sedimentation tank that utilized part of the water treatment facility, the capability of massive processing was improved. At the same time, water quality was also improved due to the simplified aeration realized by a temporary blower. In order to assure the power supply for regular and temporary equipment and units, temporary incoming substation equipment was procured, installed, and connected through cables. For the reduction of operation and control manpower for wastewater pumping, a temporary monitoring and control facility was installed in the central monitor room of the control building.

**Fig. 1** **Temporary Outdoor Incoming Substation Facilities at the Kennan WPC**

Temporary outdoor incoming substation facilities were installed to secure the power source for wastewater pumps, etc.

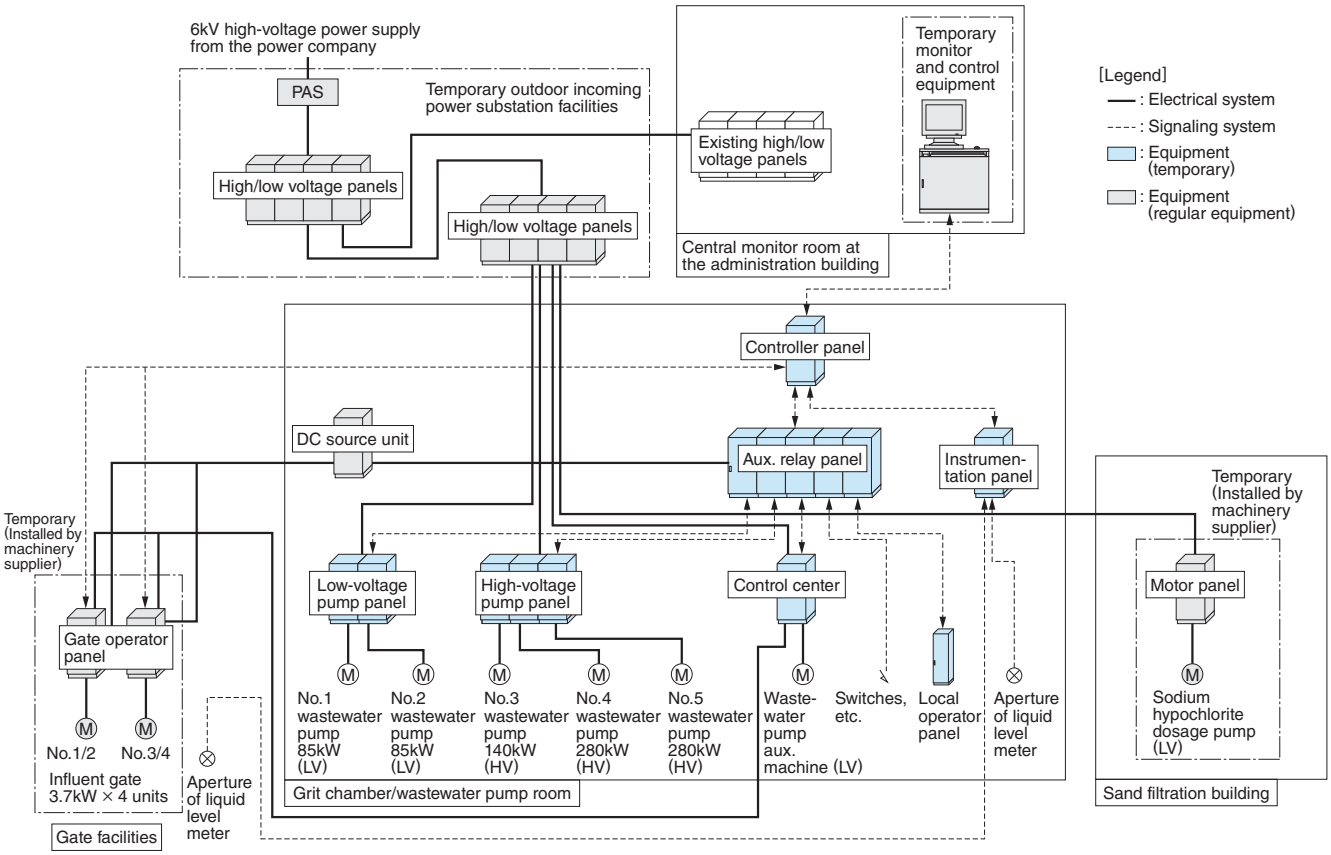


**Fig. 2** **Schematic Diagram of the Kennan WPC at the Stage of Recovery**

With the installations of temporary outdoor incoming substation facilities, the power source for various equipment and units were recovered. Wastewater pumps were monitored and controlled from the temporary monitor and control system.

To protect against the tsunami caused by a great earthquake in the future, each building was renovated to increase waterproofing features. In addition, essential equipment and units were moved to the second and higher floors. Fig. 2 shows the schematic diagram of the system at the recovery stage.

## 3 Ofunato WPC

### 3.1 Outline of the Facilities and Condition of the Disaster

The Ofunato WPC is a water treatment site located on the right bank of the mouth of the Mori River situated in the recess of the Ofunato Bay, Iwate Prefecture. The daily maximum processing capability is 6400m$^3$/d and the processing system is based on the long-time aeration process.

This WPC was hit by the tsunami and was submerged as high as the level just beneath the second floor of the Sludge Control Building. The first floor and the basement were completely submerged. Most facilities were severely damaged except for the electrical equipment installed in the operator room on the second floor of the control building. Fig. 3 shows situation of damage at the upper area.

### 3.2 Situation of Restoration

In order to secure the pumping-up function for influent wastewater, the wastewater pump was temporarily restored. The power supply was secured with the use of a temporary generator. The pumped-up wastewater was delivered through the temporarily installed piping system to a reactor tank used as a temporary sedimentation tank so that we could secure functions for the water processing sequence of pump-up – settling – sterilization – effluent.

Fig. 3 Situation of Damage at the Upper Area of the Site in the Ofunato WPC

The upper area of the WPC facilities was critically damaged by the direct hit of the tunami.

Along with the recovery of the power supply from the power company, a temporary incoming power facility and wastewater pump control panel were installed to assure functions of automatic operation based on the water level of the wastewater pump. After that, a single system of a water purification facility was recovered using the temporary motor control panel.

Our supporting activities for the sludge treatment facilities were made for the goal of complete restoration. These facilities began working after one year after the Quake. Since then, incoming power substation and water purification facilities were in turn recovered. Complete restoration of all facilities was achieved in one year and seven months (actual construction time: 15 months). Since the first floor and lower part of the facilities were damaged by submersion on account of the tsunami, we had to remove mud and sand, debris, sludge, oil, drift timber from other factories, and rotten fish from rooms, followed by laborious cleaning. Subsequently, we concentrated ourselves on remedial restoration of water purification facilities as well as procuration of a temporary incoming power substation and water purification facilities and working on equipment installation and cabling. To relieve operation control burden from workers on the site, we installed temporary remote monitoring devices that use a mobile phone network. In order to prepare against tsunami caused by a great earthquake in the future (the level of the past great earthquake in Chile), we made arrangements to protect essential power incoming substation facilities. Waterproof and submersion preventive measures were given to the open parts of the incoming power substation and in-house power generating system room located on the first floor. (During reconstruction work, a cut-off wall of about 1m tall was installed at the entrance into the room.)

## 4 Kesennuma WWTP

### 4.1 Outline of the Facilities and Situation of Disaster

The Kesennuma WWTP is a wastewater treatment site located at the mouth of the Okawa River situated in Kesennuma City, Miyagi Prefecture. The

daily maximum processing capability is 9800m³/d and the processing system is based on the anaerobic-oxic activated sludge process.

Damage in electrical facilities was caused by submersion as a result of tsunami and all wastewater treatment facilities were damaged. Machinery facilities were also devastatingly damaged. The damage then showed that treatment functions were completely lost and early recovery was impossible to achieve. Fig. 4 shows a view of damage in the control and monitor room of the main administration building.

**Fig. 4** Situation of Damage in the Control and Monitor Room at the Kesennuma WWTP

The monitor room in the second floor of the administration building was directly hit by the tsunami and the WWTP site was destroyed.

## 4.2 Recovery Situation

In order to dispose of sludge generated in the temporary treatment facilities in the city, we took measures to attain complete recovery of the sludge treatment, sand filtration, and sterilization facilities. The incoming power substation and monitoring-control facilities were planned to be installed in the new administration building that was to be constructed. As remedial measures taken to support this WWTP, the power supply was tentatively taken from a temporary outdoor power incoming substation facility and monitoring and control were carried out from temporary monitoring and control system installed in the monitor room of the sludge treatment building. Fig. 5 shows a schematic diagram used at the stage of recovery.

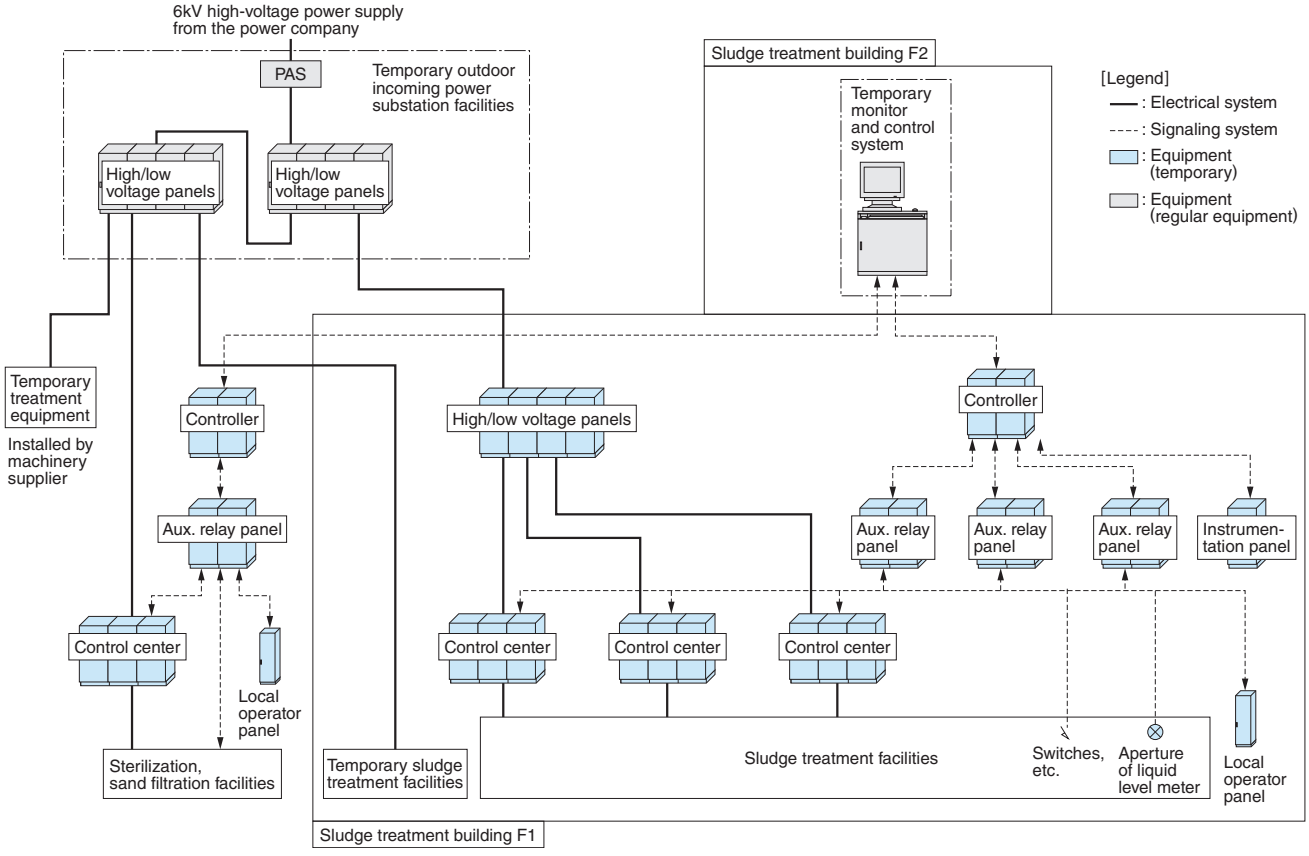


**Fig. 5** Schematic Diagram of the Kesennuma WWTP at the Stage of Recovery

Temporary incoming power substation and monitor and control system were installed in the administration building before regular construction.

Switchgear and panels were installed such that the windows and doors of each electricity room were destroyed. In order to avoid salt and other damage, we took special measures to produce and install temporary doors for electricity rooms. Due to construction work, it became impossible for any maintenance personnel to stay at night. As such, we temporarily installed a simplified remote monitoring system that uses a mobile phone network in order to perform remote monitoring and emergency communication.

## 5 Yonai WPC and the High-Voltage Mobile Power Generating System

As a remedial measure taken against power outage, WPPs in Morioka City, Iwate Prefecture, received electric power from emergency in-house power generating plants and from the power company through a 2-line power transmission system. In the case of the Quake, however, the power supply from the power company was suspended and the Yonai WPC with the 2-line power receiving facilities had to suspend transmission and distribution of purified water. For this reason, a mobile power generating system was installed on-site. Fig. 6 shows an external appearance of the mobile power generating system. The features of the dispatched mobile power generating system are described below.

(1) Since the source voltage is high, existing high-voltage conveying pumps can be operated.

(2) The connector panel was installed. The connection of high-voltage cables to the existing incoming power substation facilities could therefore, be easily made.

(3) The total mass of the mobile power generating system vehicle is suppressed to not exceed 8t. A truck driver can therefore move this system to any place.

Since a vehicle of the high-voltage mobile power generating system was ready for servicing, we could assure stable operation of facilities even in the case of power outage.


**Fig. 6** Mobile Power Generating System at the Yonai WPC in Morioka City

It can make cable connections to the rear of the vehicle. Electric power can be supplied when cables are connected to the distribution substation facilities of the Purification Center.

## 6 Postscript

This paper introduced our work in regard to the initial recovery of wastewater treatment facilities after the incident of the Quake and our repair work for waterworks facilities. In the state of extreme confusion shortly after the Quake, we drew up an initial recovery plan with our customers under very worst conditions. In consideration of the volume of water to be treated, power demand, and other basic factors, engineering services to cover overall plant facilities were required, including expertise for not only electric facilities but also civil-engineering and architectural technologies. We hope that our knowledge and expertise obtained through our recovery work as a result of the Quake can be a guide to our future recovery plans in case of any reoccurrence of another earthquake in the future.