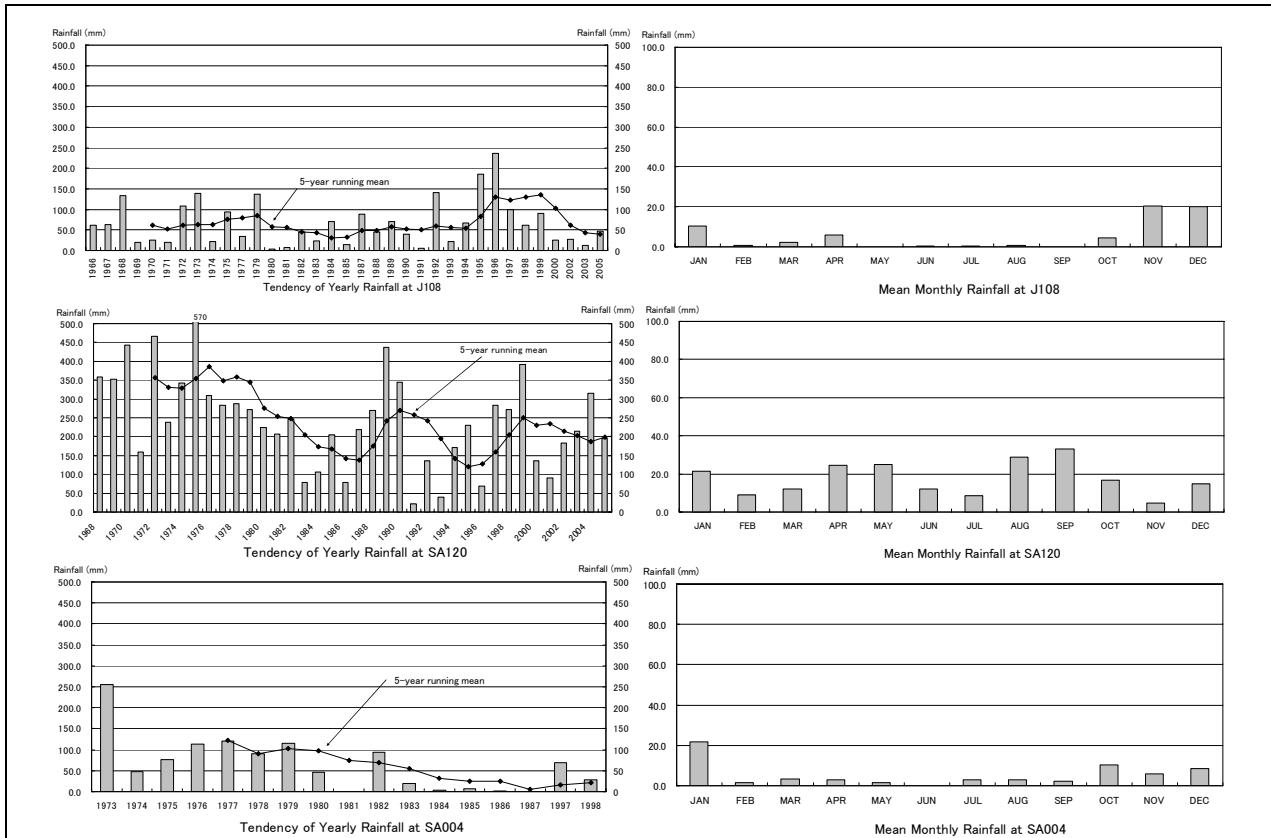


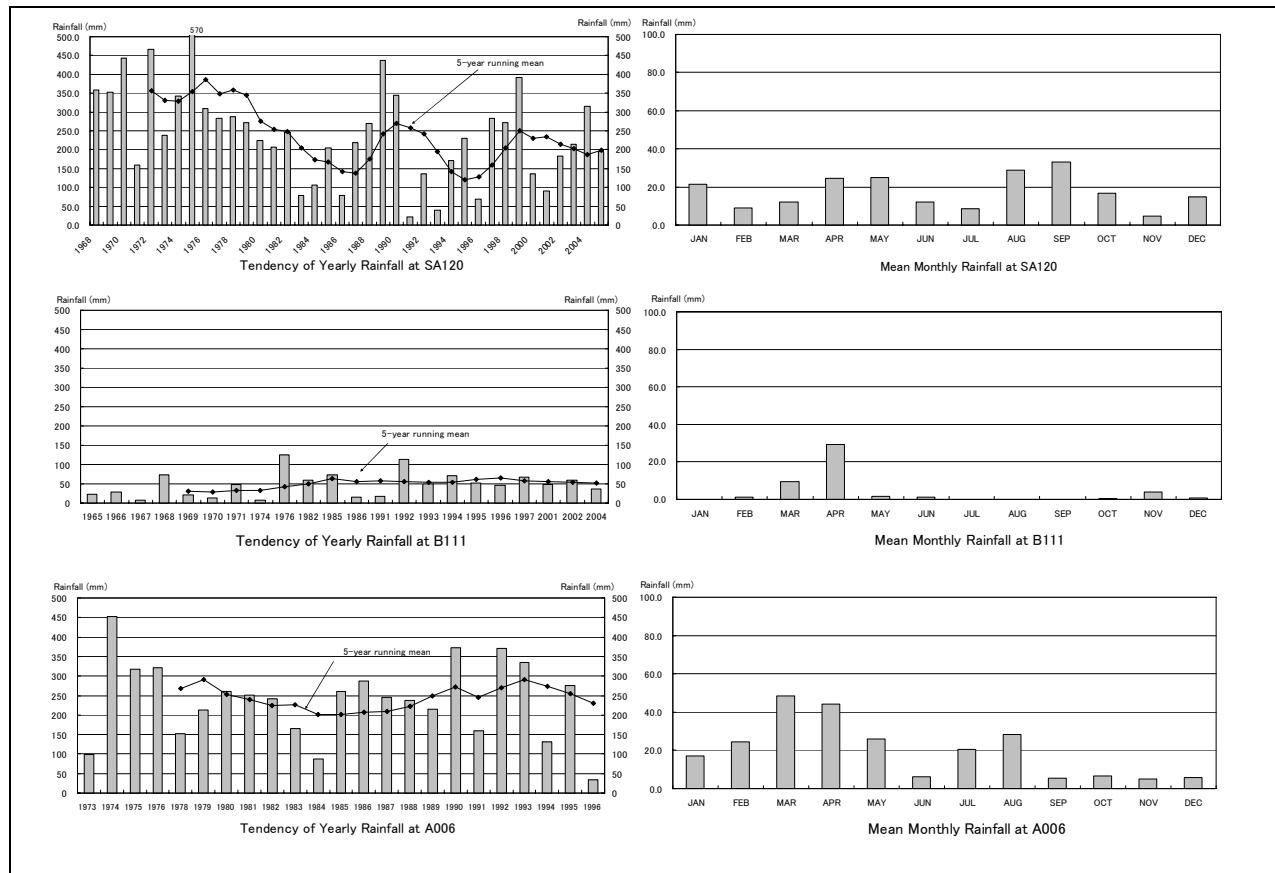
Sources:MOWE

Figure 2-5(1) Change Over Years and Monthly Rainfall Distribution in Northern Part



Sources:MOWE

Figure 2-5(2) Change Over Years and Monthly Rainfall Distribution in Southern Part



Sources: MOWE

Figure 2-5(3) Change Over Years and Monthly Rainfall Distribution in Eastern Part

(2) Al Baha Region

There are 7 Rainfall Stations under the control of MOWE as shown in Figure 2-6, besides these stations, PME has 1 Rainfall Gauge. The tendencies for rainfall distribution are arranged and shown in Figure 2-7 based on the typical stations data.

The rainfall characteristics in Al Baha Region are summarized below.

- Annual Rainfall varies rises or falls fluctuating widely every year.
- There is a lot of rain with over 200 mm, even to 300 mm in mean annual rainfall in the center of the Al Baha Region, where is situated near the neighborhood of Hijaz Asir Highland.
- On the other hand, there is about 100 mm in the northeast, 100 mm to 200 mm in the southwest in mean annual rainfall.
- There is a lot of rain through November into May, and a little rain through June into September.
- As there is a lot of rain in the center of Al Baha Region, the water resources potential is also expected in this area, but it seems to be small amount because of small area.
- The mean annual rainfall of Al Baha Region is 200 mm calculated by the Isohyetal Map.

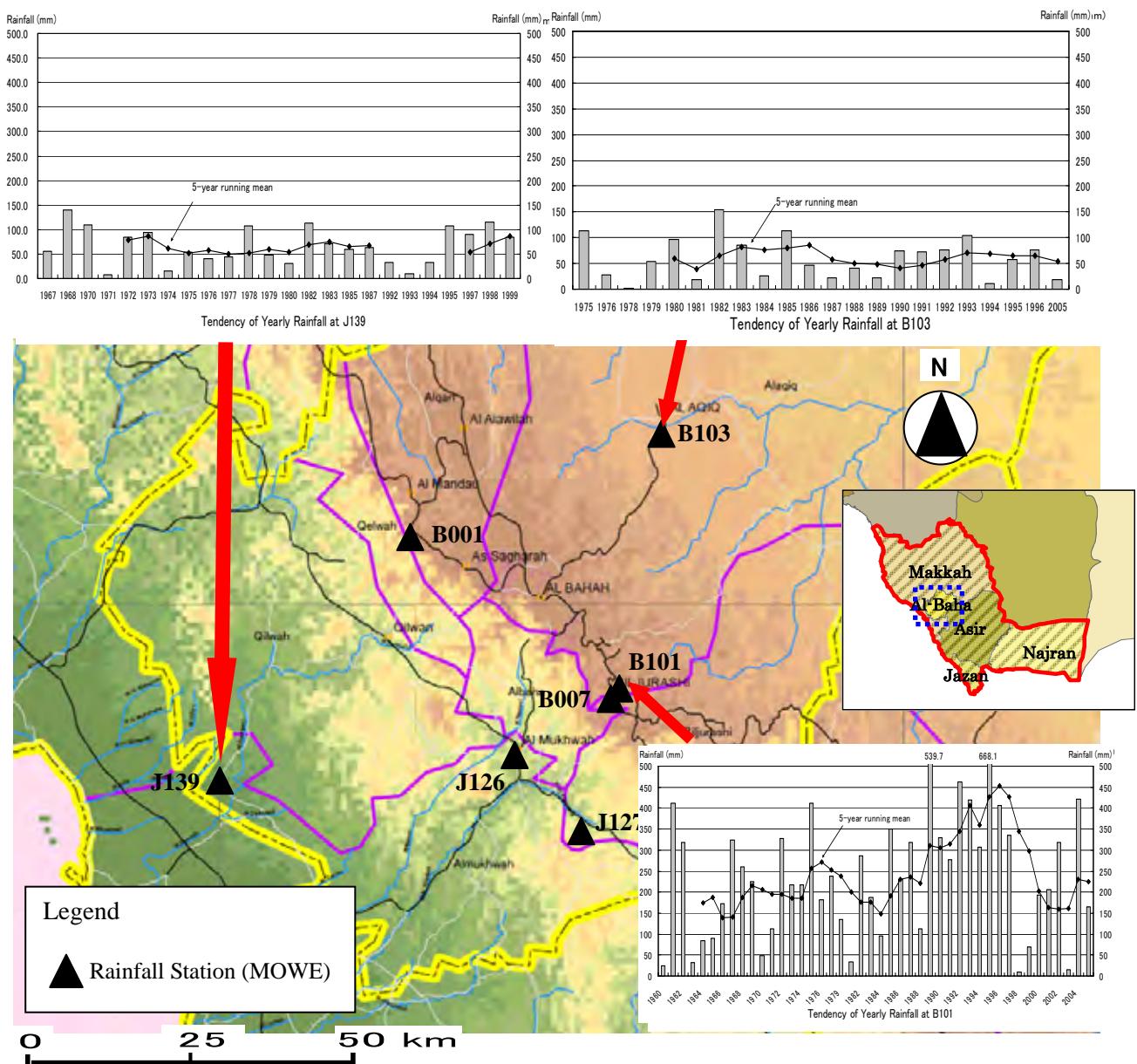
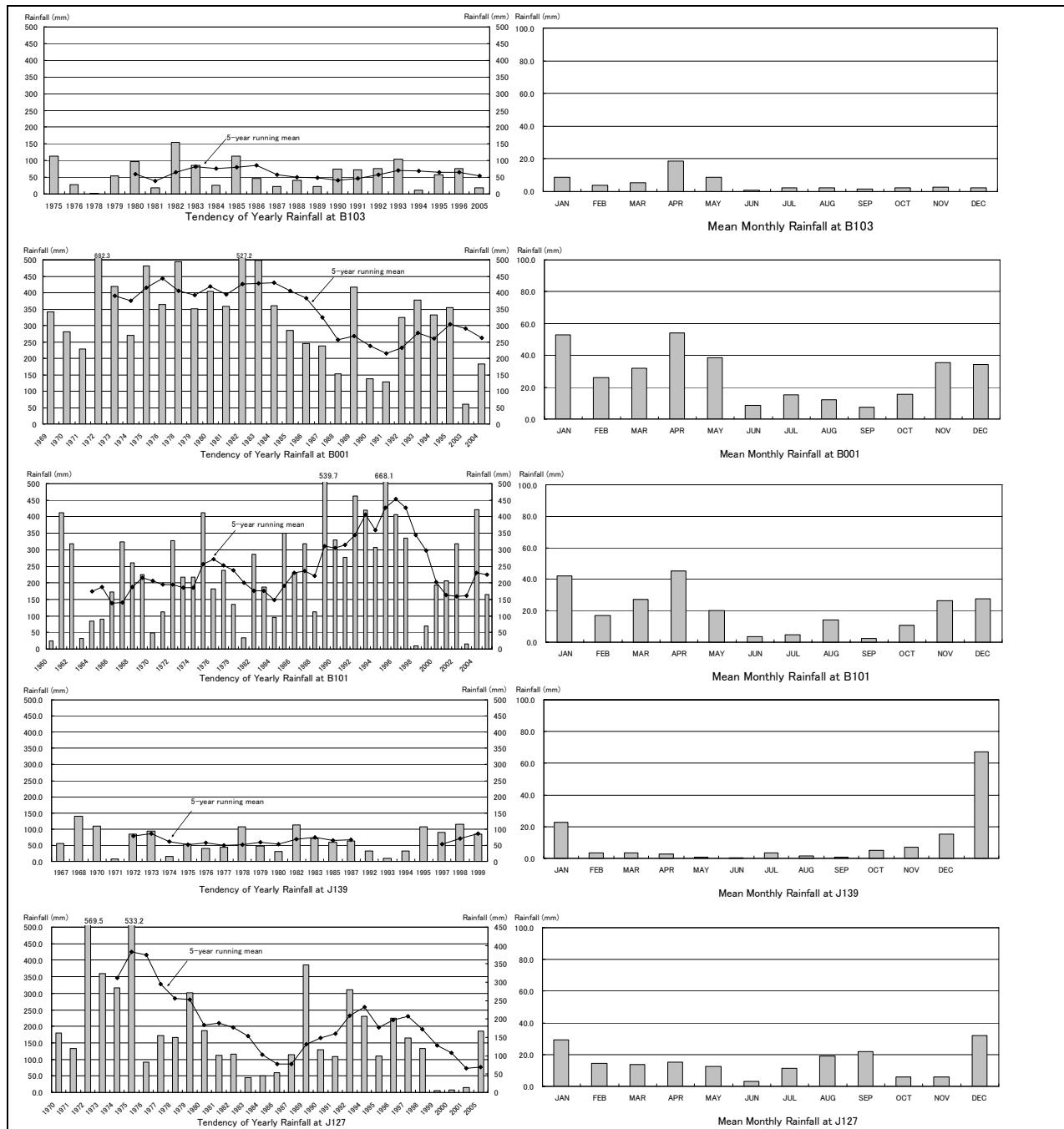


Figure 2-6 Rainfall Stations in Al Baha Region



Sources: MOWE

Figure 2-7 Change Over Years and Monthly Rainfall Distribution of Typical Station

(3) Asir Region

There are 43 Rainfall Stations under the control of MOWE as shown in Figure2-8, besides these stations, PME has 2 Rainfall Gauges. The tendencies for rainfall distribution are arranged and shown in Figure2-9 based on the typical stations data.

The rainfall characteristics in Asir Region are summarized below.

- Annual Rainfall varies rises or falls fluctuating widely every year.
- There is a lot of rain with over 200 mm, even to 300 mm in mean annual rainfall in the western part of the Asir Region, where is covered with Hijaz Asir Highland.
- On the other hand, there is 50 mm below in mean annual rainfall in most eastern part.
- Although there is a lot of rain in some area of western part through July into September, there is a lot of rain through March into May largely.
- As mentioned above, there is a lot of rain in the western part of Asir Region, the water resources potential seems to be also limited in this area.
- The mean annual rainfall of Asir Region is 90 mm calculated by the Isohyetal Map, but in case of the limited area where excluding the eastern part covered 50 mm below in mean annual rainfall is 191 mm.

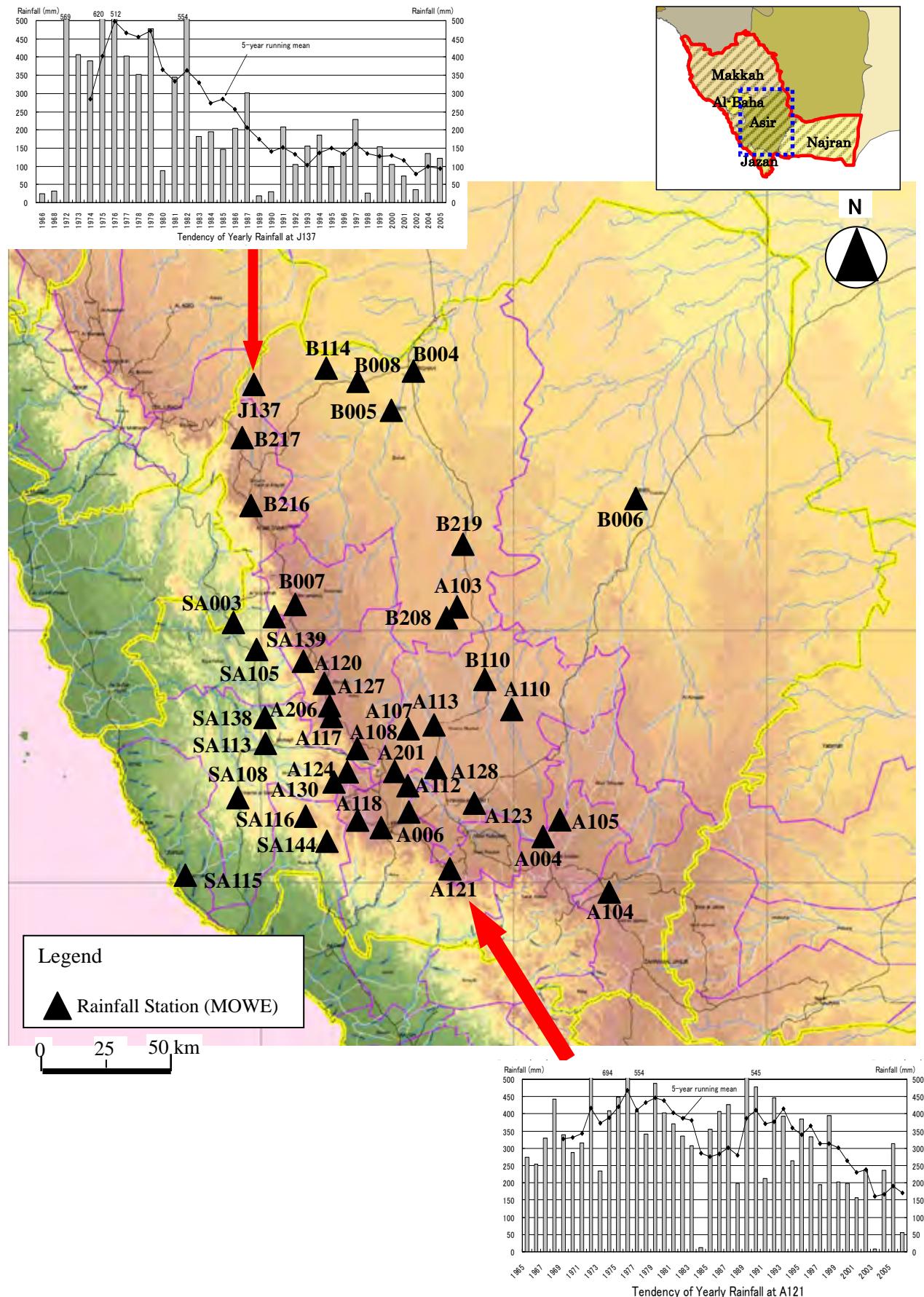
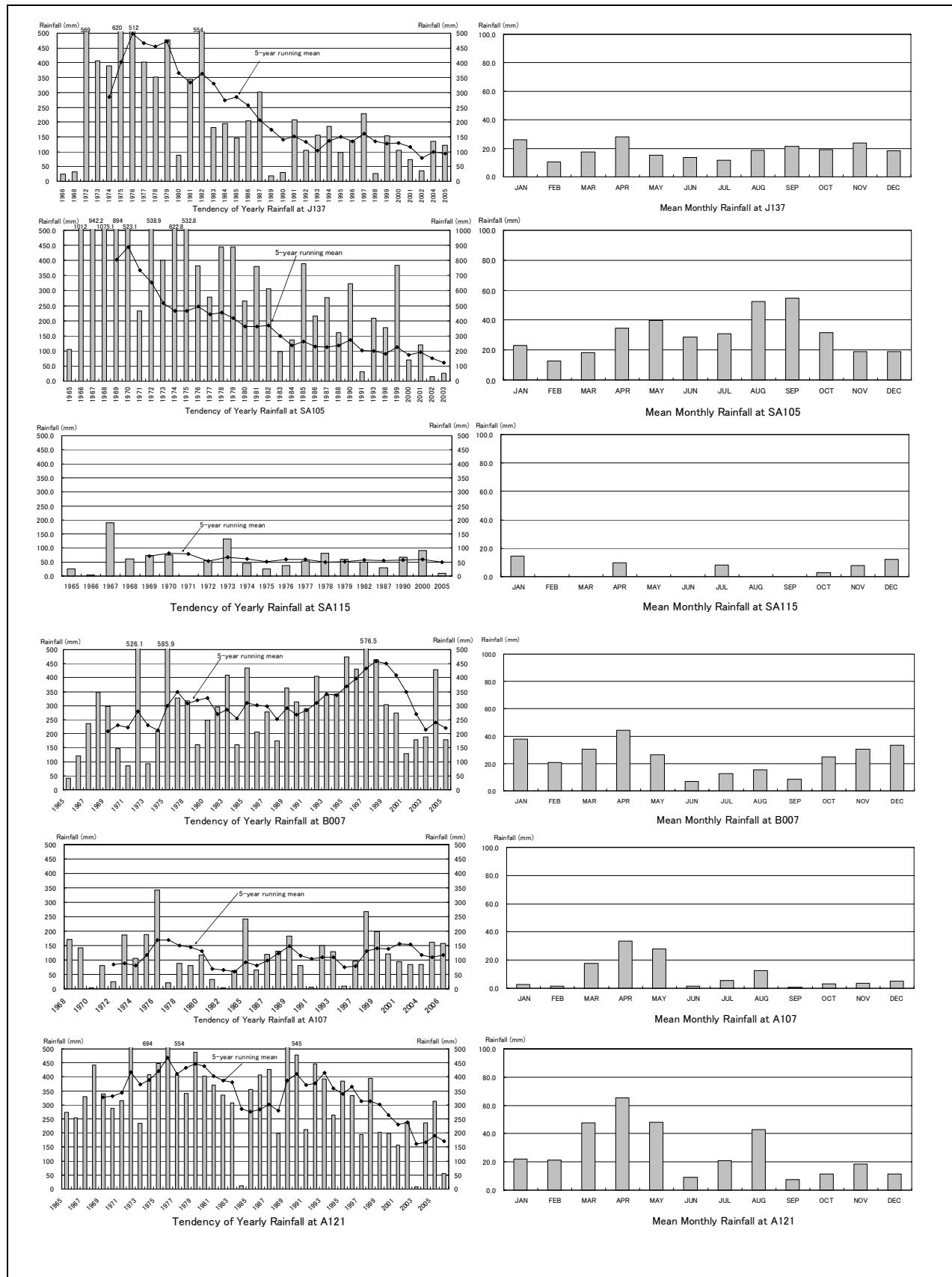
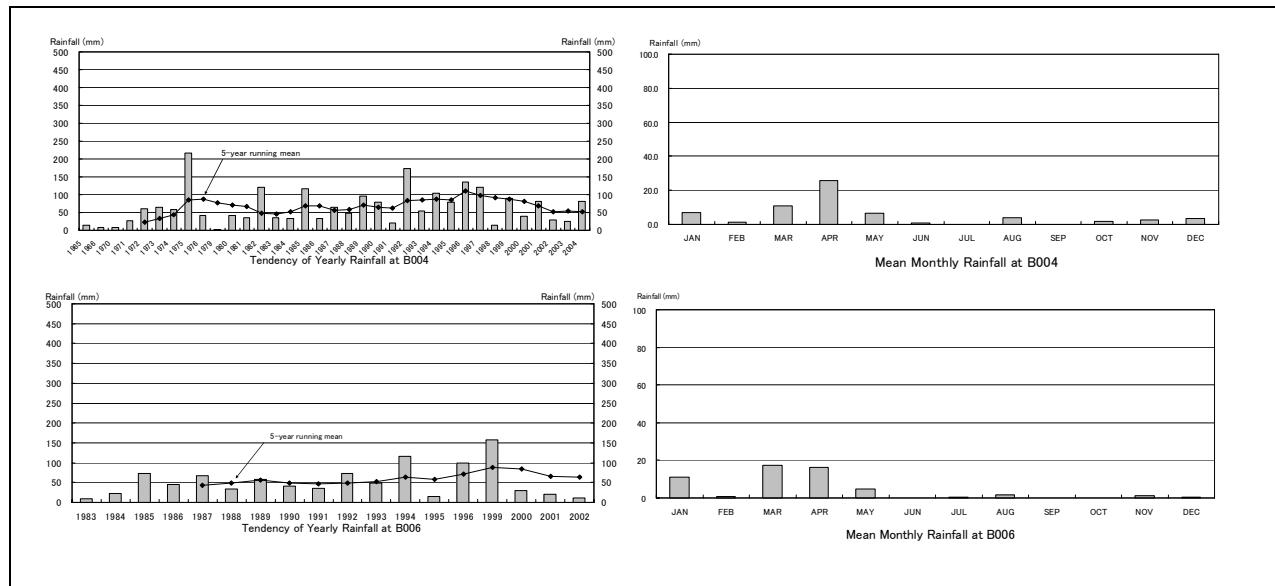


Figure2-8 Rainfall Stations in Asir Region



Sources: MOWE

Figure 2-9(1) Change Over Years and Monthly Rainfall Distribution in Western Part



Sources: MOWE

Figure 2-9(2) Change Over Years and Monthly Rainfall Distribution in Eastern Part

(4) Jazan Region

There are 20 Rainfall Stations under the control of MOWE as shown in Figure 2-10, besides these stations, PME has 1 Rainfall Gauge. The tendencies for rainfall distribution are arranged and shown in Figure 2-11 based on the typical stations data.

The rainfall characteristics in Jazan Region are summarized below.

- Annual Rainfall varies rises or falls fluctuating widely every year.
- There is a lot of rain with over 200 mm, even to 400 mm or 500 mm in mean annual rainfall from the center to the eastern part of the Jazan Region, where is covered with Hijaz Asir Highland.
- It seems to be a tendency of rainfall decreasing in the direction of the southwest, and there is 100 mm below in mean annual rainfall in the western part facing the Red Sea.
- There is a lot of rain through July into September, even though there is a lot of rain through March into April in some area.
- As mentioned above, there is a lot of rain in the center and eastern part of Jazan Region, the water resources potential seems to be also expected in this area.
- The mean annual rainfall of Jazan Region is 243 mm calculated by the Isohyetal Map.

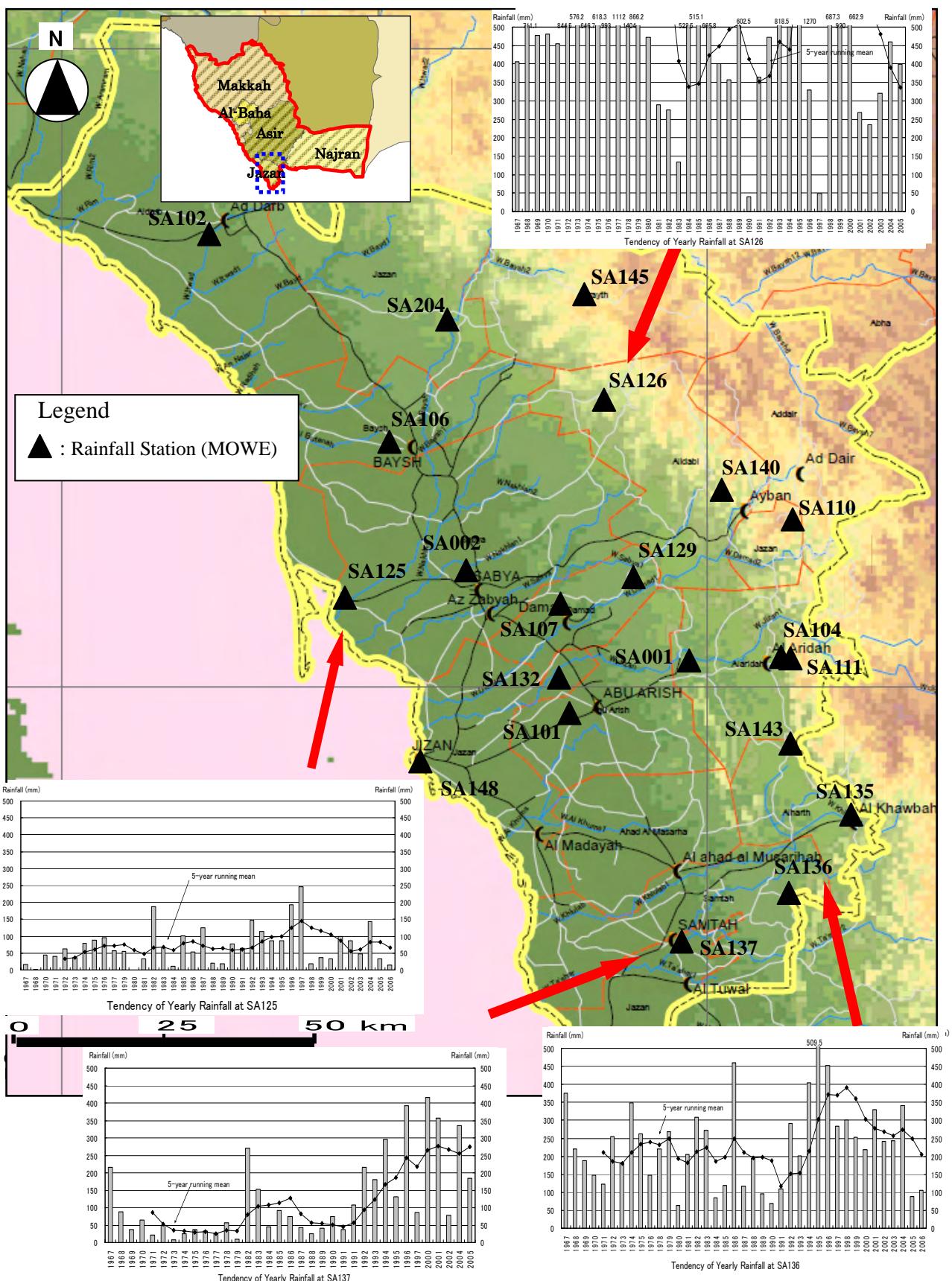
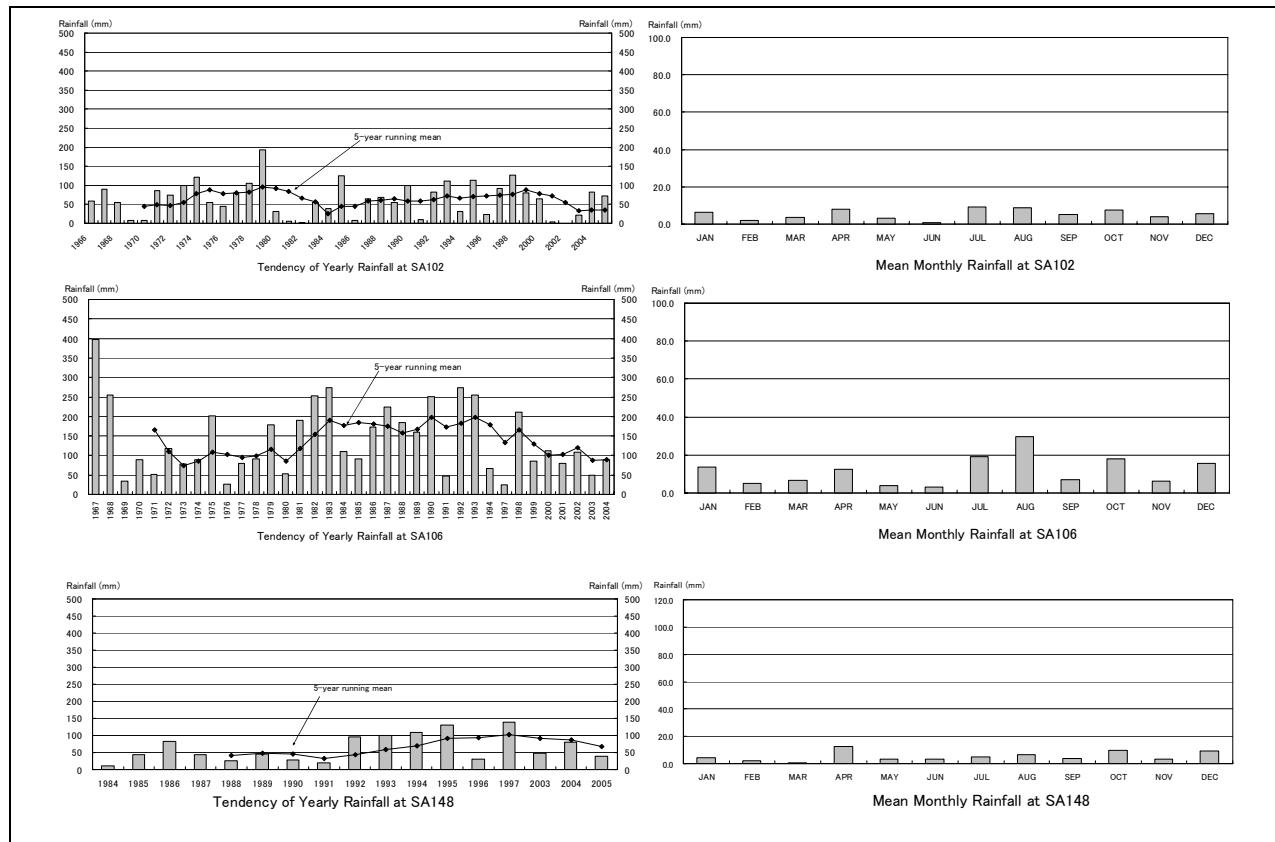
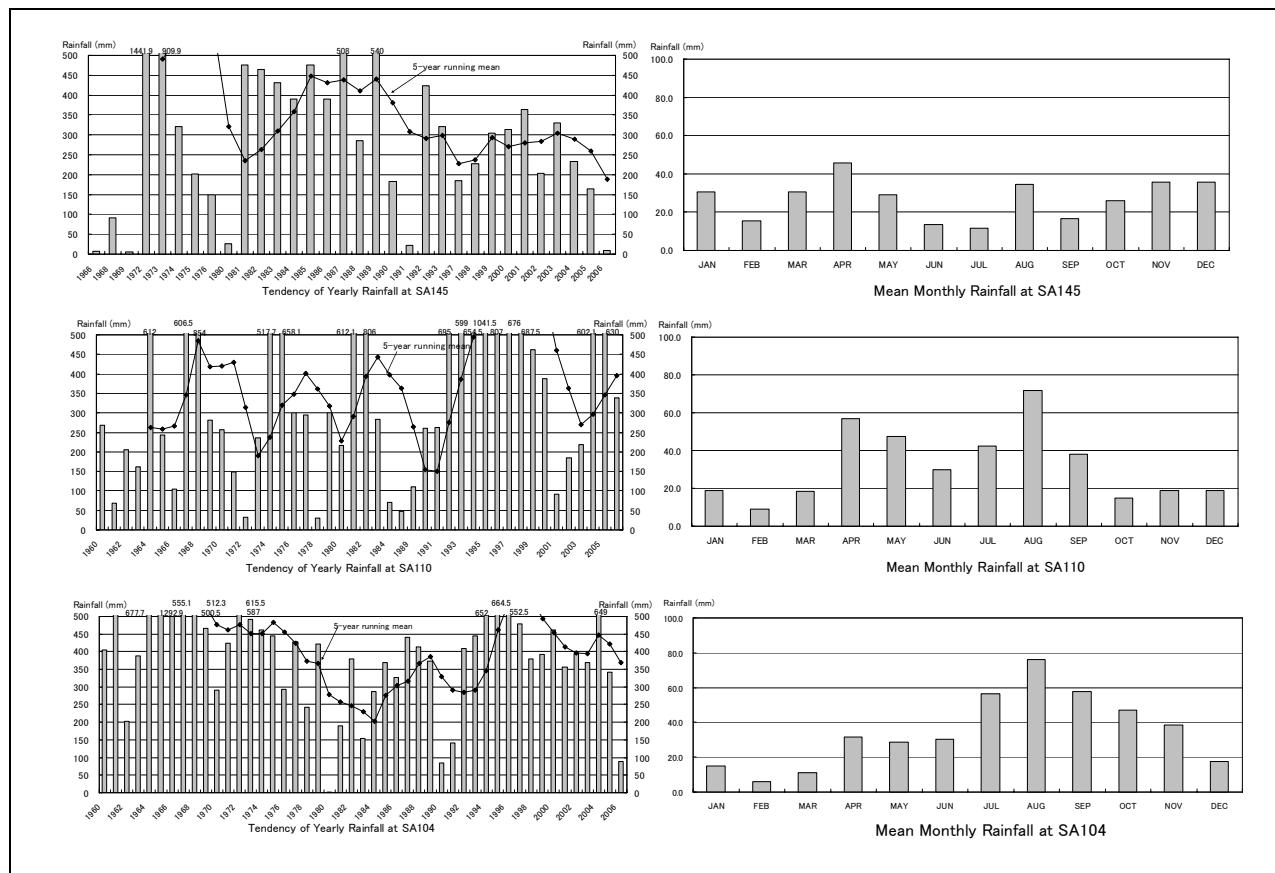


Figure 2-10 Rainfall Stations in Jazan Region



Sources: MOWE

Figure 2-11(1) Change Over Years and Monthly Rainfall Distribution in Western Part



Sources: MOWE

Figure 2-11(2) Change Over Years and Monthly Rainfall Distribution in Eastern Part

(5) Najran Region

There are 2 Rainfall Stations under the control of MOWE as shown in Figure2-12, besides these stations, PME has 1 Rainfall Gauge. The tendencies for rainfall distribution are arranged and shown in Figure2-13 based on the typical stations data.

The rainfall characteristics in Najran Region are summarized below.

- There is a limited area with 50 mm to 100 mm in mean annual rainfall, near the boundary of Asir Region.
- It seems that most of Najran Region is covered by the desert with 50 mm below in mean annual rainfall, though it can not affirm because of there being not any rainfall station in those area.
- There is a lot of rain through March into May.
- Although there is a limited area with 50 mm to 100 mm in mean annual rainfall in the western part of Najran Region, the water resources potential seems to be not much because of most of the Region being covered by the desert with 50 mm below in mean annual rainfall.
- The mean annual rainfall of Najran Region is 26 mm calculated by the Isohyetal Map.

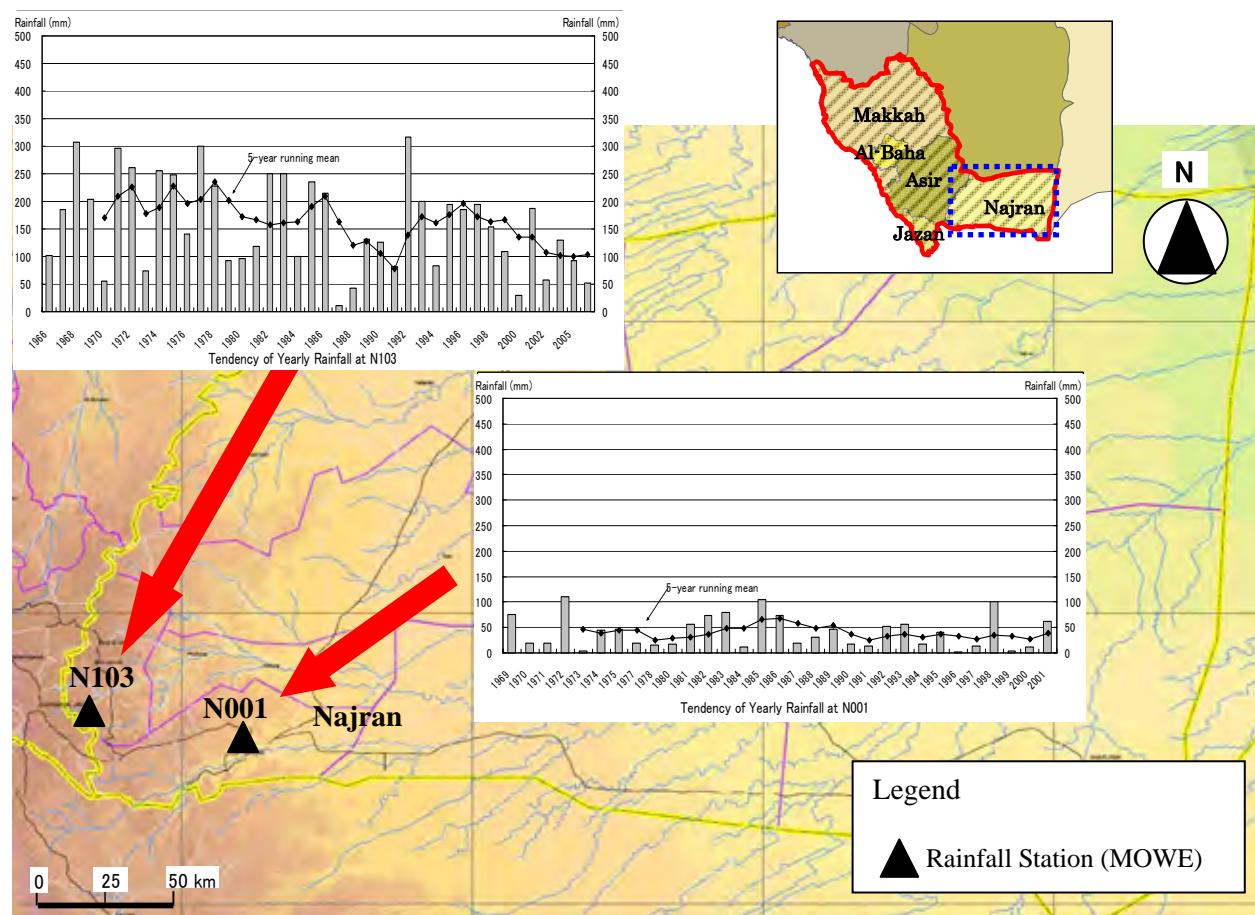
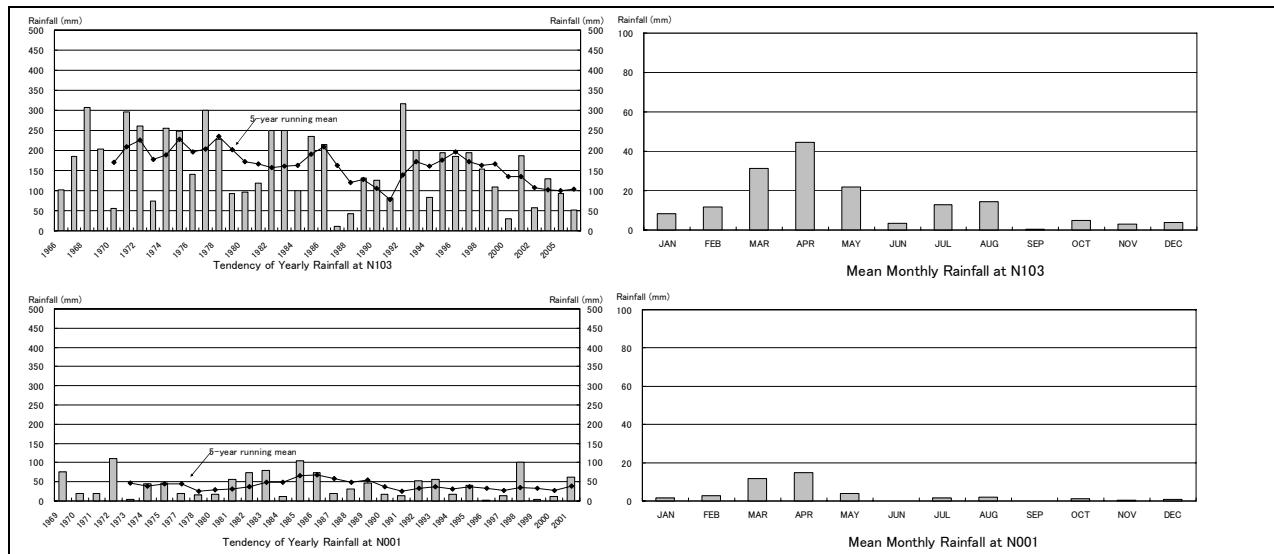


Figure2-12 Rainfall Stations in Najran Region



Sources: MOWE

Figure 2-13 Change Over Years and Monthly Rainfall Distribution in Najran Region

3. Surface Flow

3.1 Flow Characteristics in the Study Area

Tendencies for flow distribution are arranged and shown in Figure 3-1 based on the flow data of the typical stations shown in Figure 3-2. And the specific flow and others are shown in Table 3-1.

The flow characteristics in the study area are summarized below with reference to the figure and table.

- Mean Specific Flow in the study area ranges between $2,452 \text{ m}^3/\text{km}^2/\text{year}$ (2.5 mm/year) and $44,820 \text{ m}^3/\text{km}^2/\text{year}$ (44.8 mm/year).
- There is a relatively small mean specific flow with around $3,000 \text{ m}^3/\text{km}^2/\text{year}$ (3 mm/year) in Northern Part.
- On the other hand, there is quite a large mean specific flow with $10,000 \text{ m}^3/\text{km}^2/\text{year}$ (10 mm/year) in the area having Hijaz Asir Highland behind the upstream.
- Above all, there is an outstanding mean specific flow with $40,000 \text{ m}^3/\text{km}^2/\text{year}$ (40 mm/year) in the south area of Jazan Region.
- Flow Ratio ranges widely from 0.022 to 0.169, and the observable fact showing small value in the northern part and large value in the southern part is consistent with the rainfall characteristics, though it is quite difficult to get high accuracy rainfall data.
- Though there are a lot of flow through July into August in some areas, most of the study area has a lot of flow through January into April.
- Specific Maximum Peak Discharge ranges between $0.05 \text{ m}^3/\text{s}/\text{km}^2$ and $0.25 \text{ m}^3/\text{s}/\text{km}^2$.
- The mean specific flow is a rather high number with $0.20 \text{ m}^3/\text{s}/\text{km}^2$ in the southern part of Jazan Region, but it is not a outstanding value.
- This reason can be explained by the fact that there is constant flow in this area all year around unlike other areas.
- As mentioned above, the phenomena of runoff in the study area match with that of the rainfall.

Table3-1 Flow and Others in the Study Area

Runoff Station	C.A. (km ²)	Eleva-tion (El.m)	Mean Flow (m ³ /year)	Mean Specific Flow (m ³ /km ² /year)	Same as the left (mm/year)	Selecte-d Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m ³ /s)	Date of Occurrence	Specific Max. Peak Discharge (m ³ /s/km ²)
J410	1,406	100	4,989,168	3,549.5	3.5	J239	56.8	1976–1981	0.062	194	Apr. 7 1975	0.14
J402	383	390	938,921	2,451.5	2.5	J113	113.9	1967–1976 1979–1981	0.022	19	Dec. 9 1976	0.05
J404	970	80	8,484,660	8,747.1	8.7	J139	64.5	1968 1970–1980	0.135	90.4	Jul. 17 1978	0.09
SA411	4,576	298	88,540,992	19,350.7	19.4	SA105	530.7	1967–1981	0.037	219	Apr. 1 1975	0.05
B402	11,350	1,140	109,197,689	9,620.9	9.6	B219	218.2	1971–1976	0.044	828	Mar. 24 1974	0.07
A403	2,285	1,800	28,702,032	12,561.1	12.6	A128	101.8	1974–1978 1981	0.124	573	Mar. 3 1970	0.25
N401	5,600	1,270	100,266,682	17,904.8	17.9	N103	202.7	1967–1976	0.088	813	Apr. 8 1969	0.15
SA417	1,000	130	39,051,619	39,051.6	39.1	SA140	408.6	1970–1981	0.096	251	Aug. 12 1975	0.25
SA421	900	99	40,337,654	44,819.6	44.8	SA135	264.7	1969–1974	0.169	176	Mar. 14 1981	0.20

Sources: MOWE

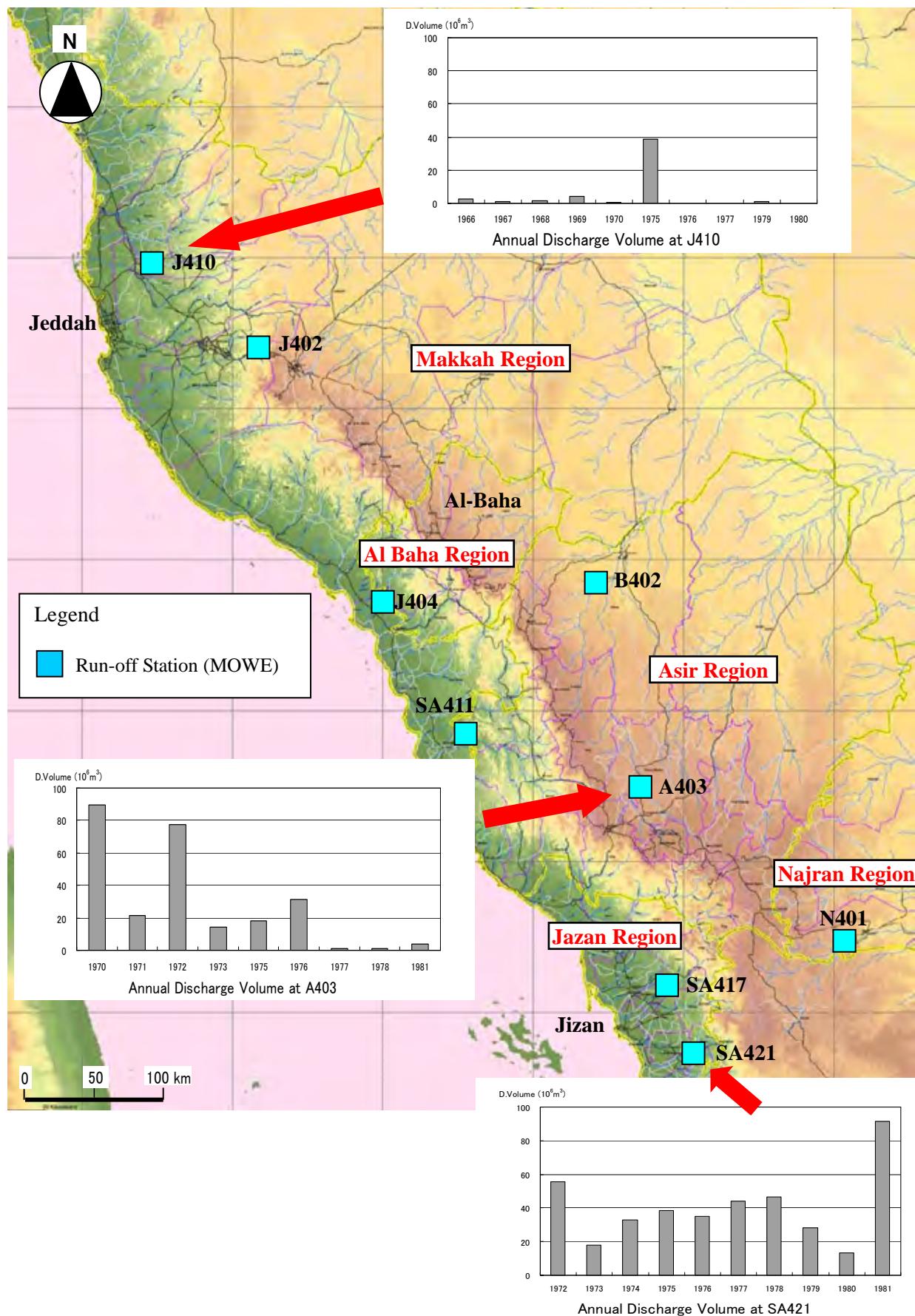
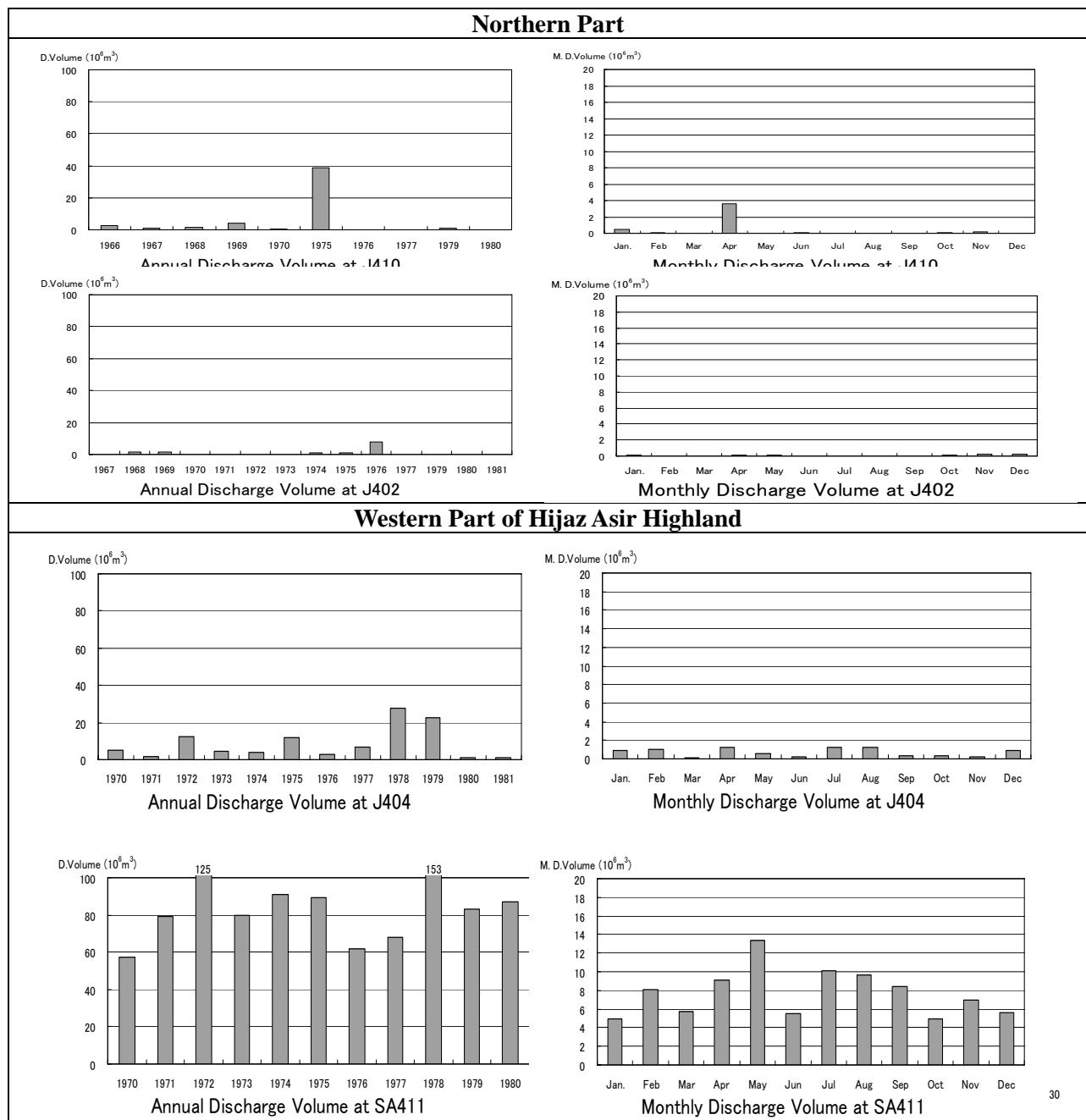


Figure3-1 Typical Runoff Stations in the study area



Sources: MOWE

Figure3-2(1) Change Over Years and Monthly Flow Distribution in Northern and Western Part

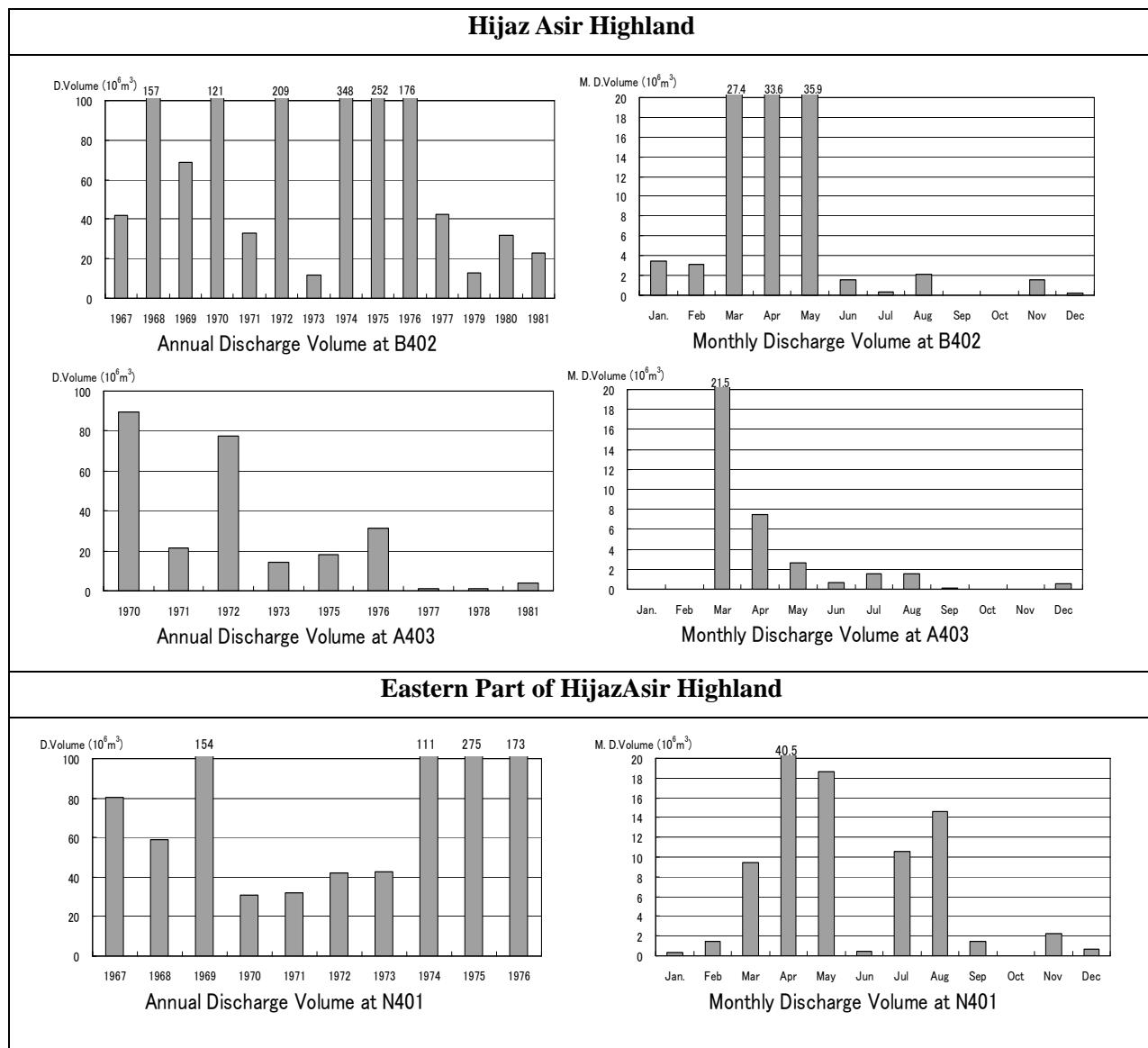
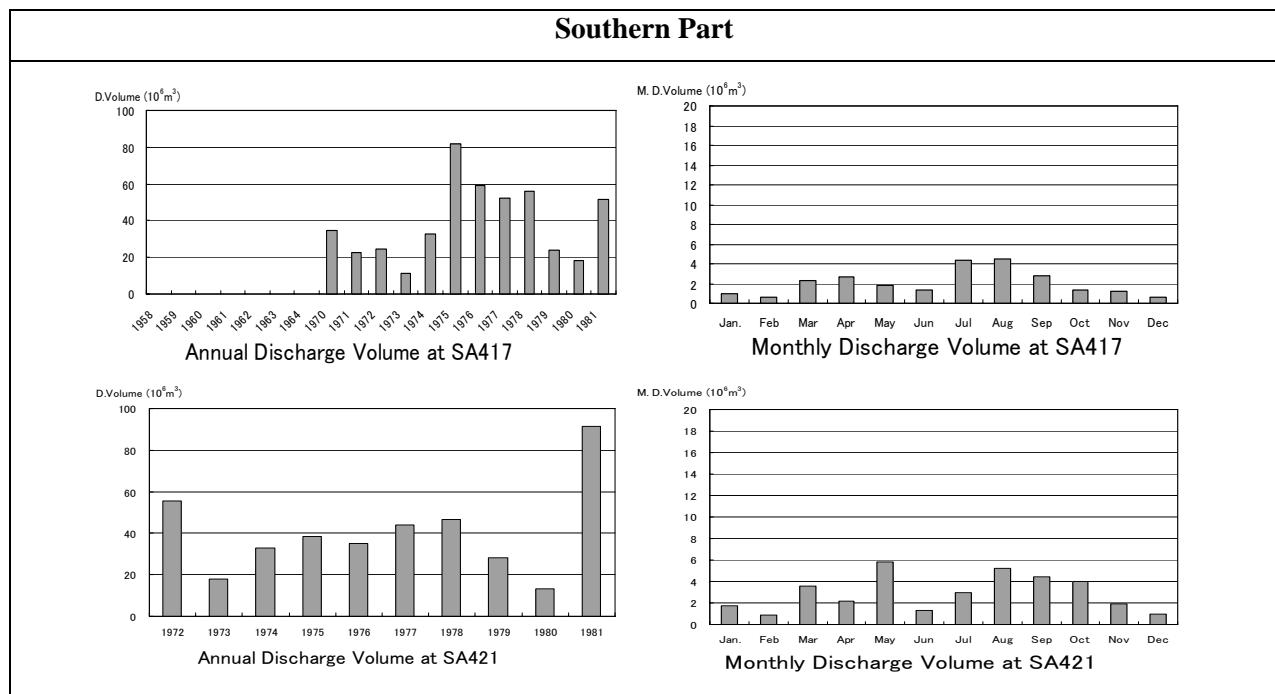


Figure3-2(2) Change Over Years and Monthly Flow Distribution in Hijaz Asir Highland and Eastern Part



Sources: MOWE

Figure3-2(3) Change Over Years and Monthly Flow Distribution in Southern Part

3.2 Flow Characteristics in Regions

(1) Makkah Region

Tendencies for flow distribution are arranged and shown in Figure3-3 based on the flow data of the typical stations shown in Figure3-4. And the specific flow and others are shown in Table3-2.

The flow characteristics in Makkah Region are summarized below.

- Annual Flow varies widely every year.
- Mean Specific Flow in Makkah Region ranges between $2,243 \text{ m}^3/\text{km}^2/\text{year}$ (2.2 mm/year) and $10,773 \text{ m}^3/\text{km}^2/\text{year}$ (10.8 mm/year) in case of the exclusion of the flatland near the Red Sea with small number as $418 \text{ m}^3/\text{km}^2/\text{year}$ (0.4 mm/year).
- Mean Specific Flow in Hijaz Asir Highland and the surrounding area and the southern area near the border with Asir Region shows high number as $10,000 \text{ m}^3/\text{km}^2/\text{year}$ (10 mm/year).
- Though Flow Ratio varies from 0.008 to 0.238, it is within 10 percent in case of the exclusion of the northern part and the southern part.
- As the flow ratio in the northern part seems to be small in consideration of the rainfall situation, the selected rainfall station data might be doubtful.
- It shows a marked tendency to be a lot of flow through January into April and a little flow through June into September.
- Specific Maximum Peak Discharge ranges between $0.01 \text{ m}^3/\text{s}/\text{km}^2$ and $0.24 \text{ m}^3/\text{s}/\text{km}^2$.
- As there is a lot of flow in the southern area near Hijaz Asir Highland, the water resources development seems to be also limited in this area.

Table3-2 Flow and Others in Makkah Region

Runoff Station	C.A. (km ²)	Eleva- tion (El.m)	Mean Flow (m ³ /year)	Mean Specific Flow (m ³ /km ² /year)	Same as the left (mm)	Selecte- d Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m ³ /s)	Date of Occurrence	Specific Max. Peak Discharge (m ³ /s/km ²)
J408	896	495	2,008,584	2,242.5	2.2	J140	16.3	1969-1970 1972-1975 1977-1979	0.138	52.4	Jan. 19 1979	0.06
J410	1,406	100	4,989,168	3,549.5	3.5	J239	56.8	1976-1981	0.062	194	Apr. 7 1975	0.14
TA405	230	1,700	783,177	3,405.1	3.4	TA206	259.6	1966-1969	0.013	21.3	Apr. 12 1968	0.09
TA401	236	1,525	2,542,514	10,773.4	10.8	TA233	223.2	1971-1981	0.048	55.7	Apr. 8 1971	0.24
J407	1,600	*	668,160	417.6	0.4	J107	47.2	1970-1977	0.008	22	Apr. 8 1975	0.01
SA401	784	420	6,643,572	8,473.9	8.5	SA120	316.7	1970-1981	0.027	30.4	Mar. 6 1974	0.04
SA402	2,722	80	25,654,616	9,424.9	9.4	SA147	77.6	1970-1981	0.121	149	Jan. 15 1977	0.05

Sources: MOWE

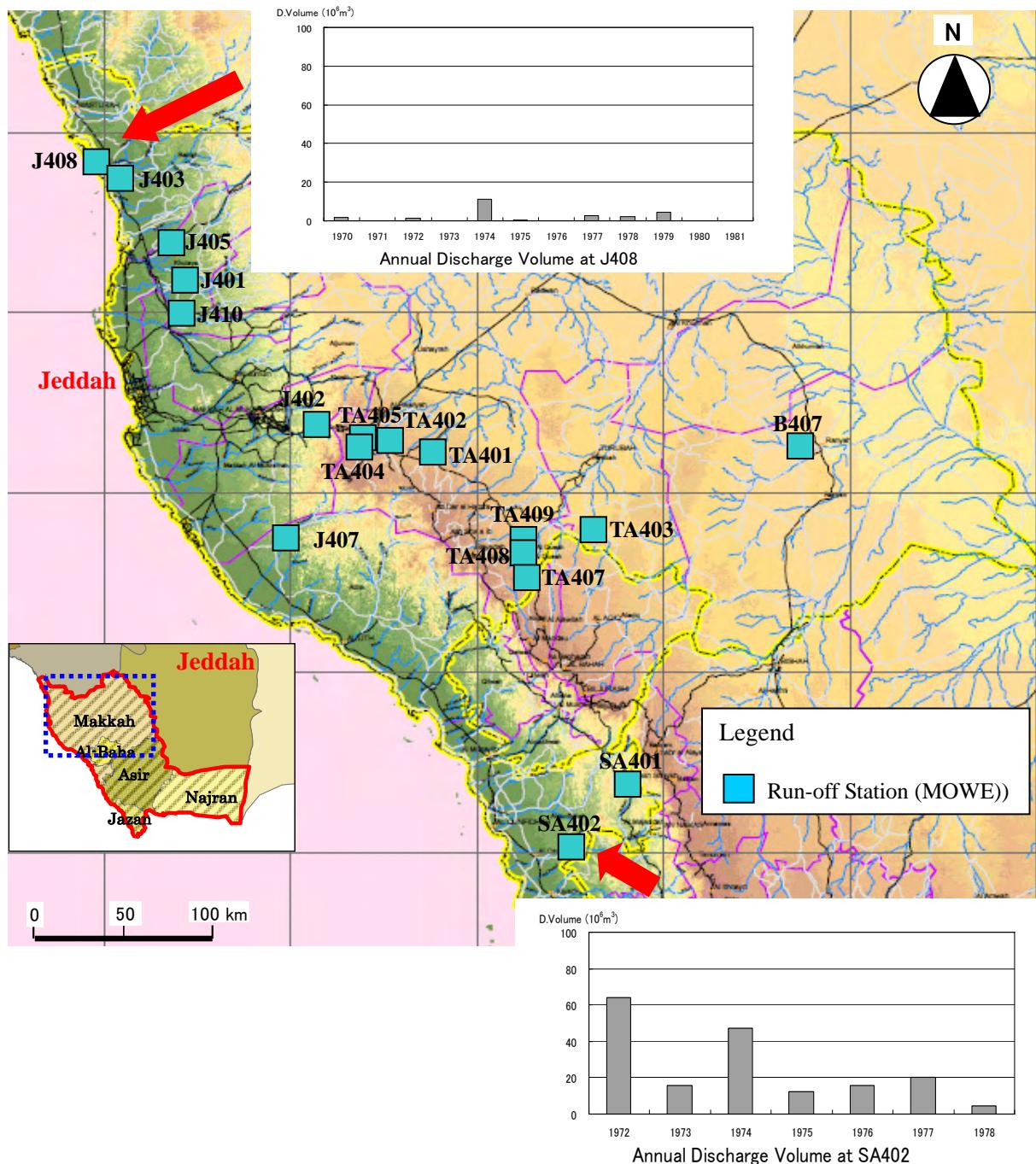
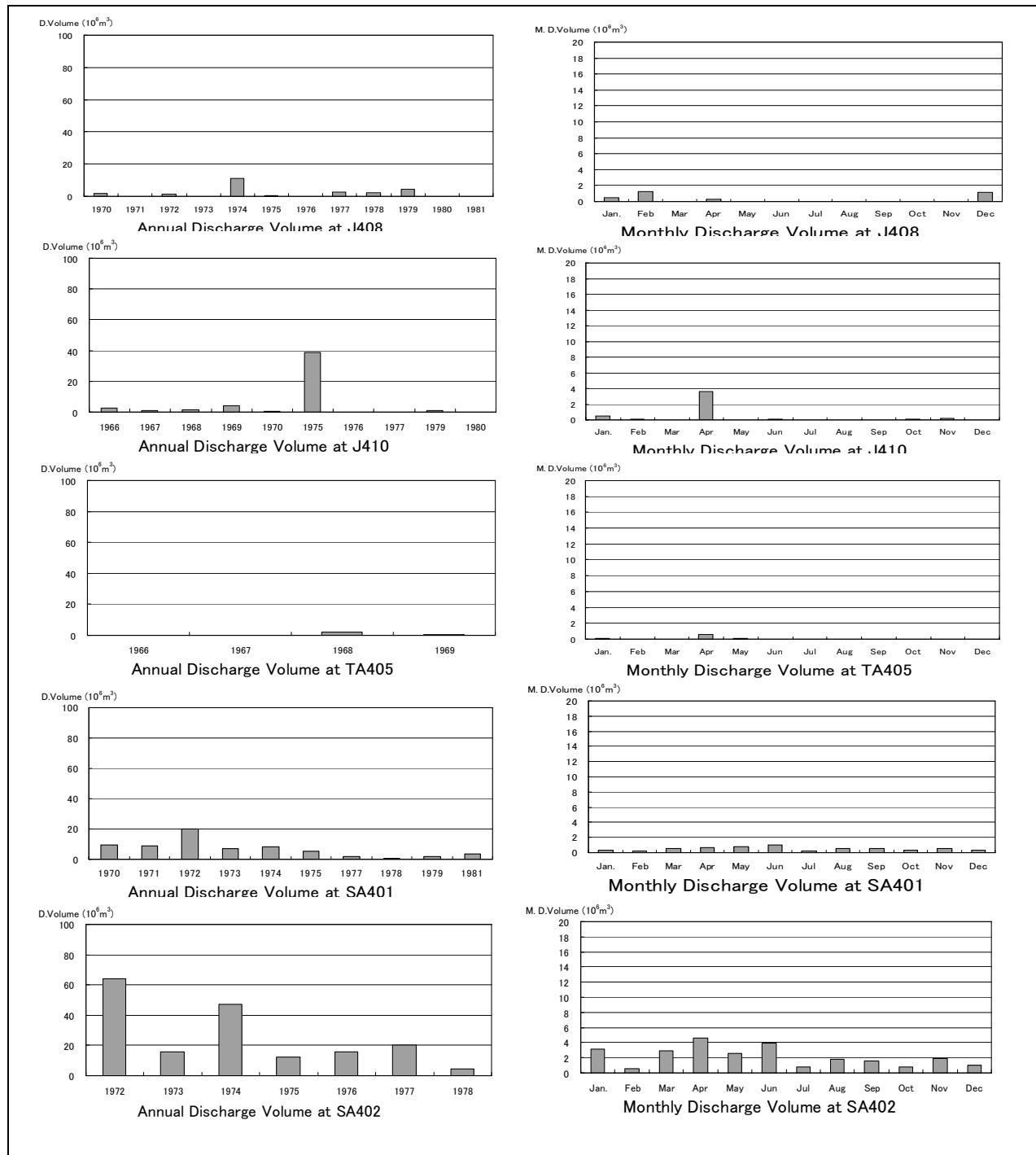


Figure3-3 Runoff Stations in Makkah Region



Sources: MOWE

Figure 3-4 Change Over Years and Monthly Flow Distribution of Typical Runoff Stations

(2) Al Baha Region

Tendencies for flow distribution are arranged and shown in Figure 3-5 based on the flow data of the typical stations shown in Figure 3-6. And the specific flow and others are shown in Table 3-3.

The flow characteristics in Al Baha Region are summarized below.

- Mean Specific Flow are $8,747 \text{ m}^3/\text{km}^2/\text{year}$ (8.7 mm/year) in the western part and $4,754 \text{ m}^3/\text{km}^2/\text{year}$ (4.8 mm/year) in the eastern part, and they seem to match the rainfall situation.
- There is a big difference between 0.135 of the western part and 0.016 of the eastern part. Judging from the rainfall situation, the selected rainfall station data for the western part might to

be small.

- There is not any outstanding month with much flow in the western part, but there are a lot of flow through January into April in the eastern part.
- Specific Maximum Peak Discharge in the western part and the eastern part are $0.09 \text{ m}^3/\text{s}/\text{km}^2$ and $0.20 \text{ m}^3/\text{s}/\text{km}^2$ respectively.
- As there seems to be a lot of flow in the western part more than the eastern part, the water resources development might be effective in this area.

Table3-3 Flow and others in Al Baha Region

Runoff Station	C.A. (km ²)	Eleva- tion (El.m)	Mean Flow (m ³ /year)	Mean Specific Flow (m ³ /km ² /year)	Same as the left (mm)	Selected Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m ³ /s)	Date of Occurrence	Specific Peak Discharge (m ³ /s/km ²)
J404	970	80	8,484,660	8,747.1	8.7	J139	64.5	1968 1970-1980	0.135	90.4	Jul. 17 1978	0.09
B408	3,290	1,360	15,641,568	4,754.0	4.8	B007	307.0	1975-1976 1978-1981	0.016	656	Apr. 8 1975	0.20

Sources: MOW.E

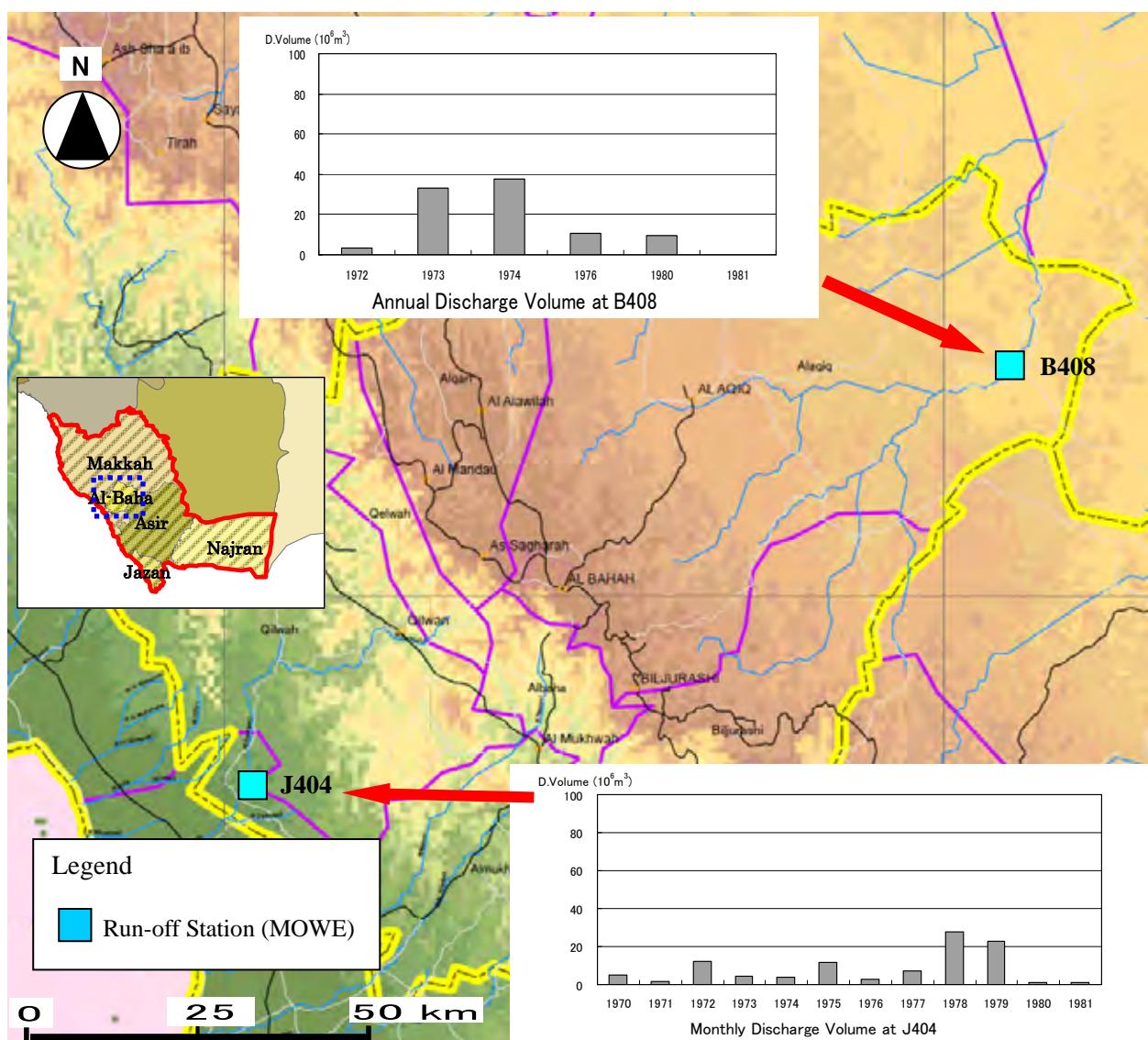
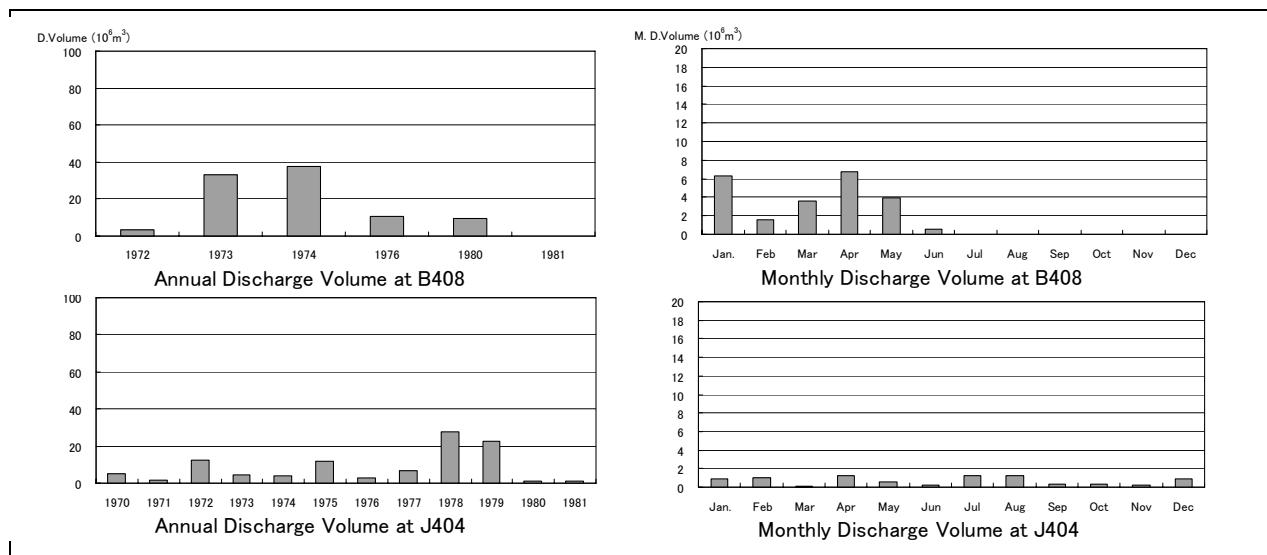


Figure3-5 Runoff Stations in Al Baha Region



Sources: MOW.E

Figure3-6 Change Over Years and Monthly Flow Distribution in Al Bahia Region

(3) Asir Region

Tendencies for flow distribution are arranged and shown in Figure3-7 based on the flow data of the typical stations shown in Figure3-8. And the specific flow and others are shown in Table3-4.

The flow characteristics in Asir Region are summarized below.

- Annual Flow varies widely every year.
- Mean Specific Flow ranges between $5,400 \text{ m}^3/\text{km}^2/\text{year}$ (5.4 mm/year) and $19,400 \text{ m}^3/\text{km}^2/\text{year}$ (19.4 mm/year) in case of the exclusion of the area near the Red Sea with extremely small number as $1,674 \text{ m}^3/\text{km}^2/\text{year}$ (1.7 mm/year), and as there are a lot of flow in Hijaz Asir Highland and the surrounding area, it matches the rainfall situation.
- Though Flow Ratio ranges between 0.025 and 0.124, it is within 5 percent in case of the exclusion of Hijaz Asir Highland and the surrounding area.
- There are a lot of flow through March into May.
- Specific Maximum Peak Discharge ranges between $0.02 \text{ m}^3/\text{s}/\text{km}^2$ and $0.25 \text{ m}^3/\text{s}/\text{km}^2$.
- Although the flow in the eastern part is not clear because of there being no runoff stations in that area, the flow seems to be concentrated in the western part owing to the rainfall situation.
- The water resources development is limited in the western part.

Table3-4 Flow and Others in Asir Region

Runoff Station	C.A. (km^2)	Eleva-tion (El.m)	Mean Flow (m^3/year)	Mean Specific Flow ($\text{m}^3/\text{km}^2/\text{year}$)	Same as the left (mm)	Selecte-d Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m^3/s)	Date of Occurrence	Specific Max. Peak Discharge ($\text{m}^3/\text{s}/\text{km}^2$)
B405	1,090	1,290	16,631,843	15,258.6	15.3	B216	330.6	1971–1981	0.046	182	Apr. 7 1975	0.17
B406	16,920	1,090	90,946,714	5,375.1	5.4	B219	218.2	1971–1976	0.025	527	Apr. 14 1975	0.03
SA411	4,576	298	88,540,992	19,350.7	19.4	SA105	530.7	1967–1981	0.037	219	Apr. 1 1975	0.05
A404	146	2,030	1,223,443	8,379.7	8.4	A201	115.9	1966–1981	0.072	12.3	Aug. 21 1977	0.08
A403	2,285	1,800	28,702,032	12,561.1	12.6	A128	101.8	1974–1978 1981	0.124	573	Mar. 3 1970	0.25
SA414	1,350	150	2,260,397	1,674.4	1.7	A006	259.4	1973–1980	0.007	22.4	Nov. 18 1973	0.02

Sources: MOW.E

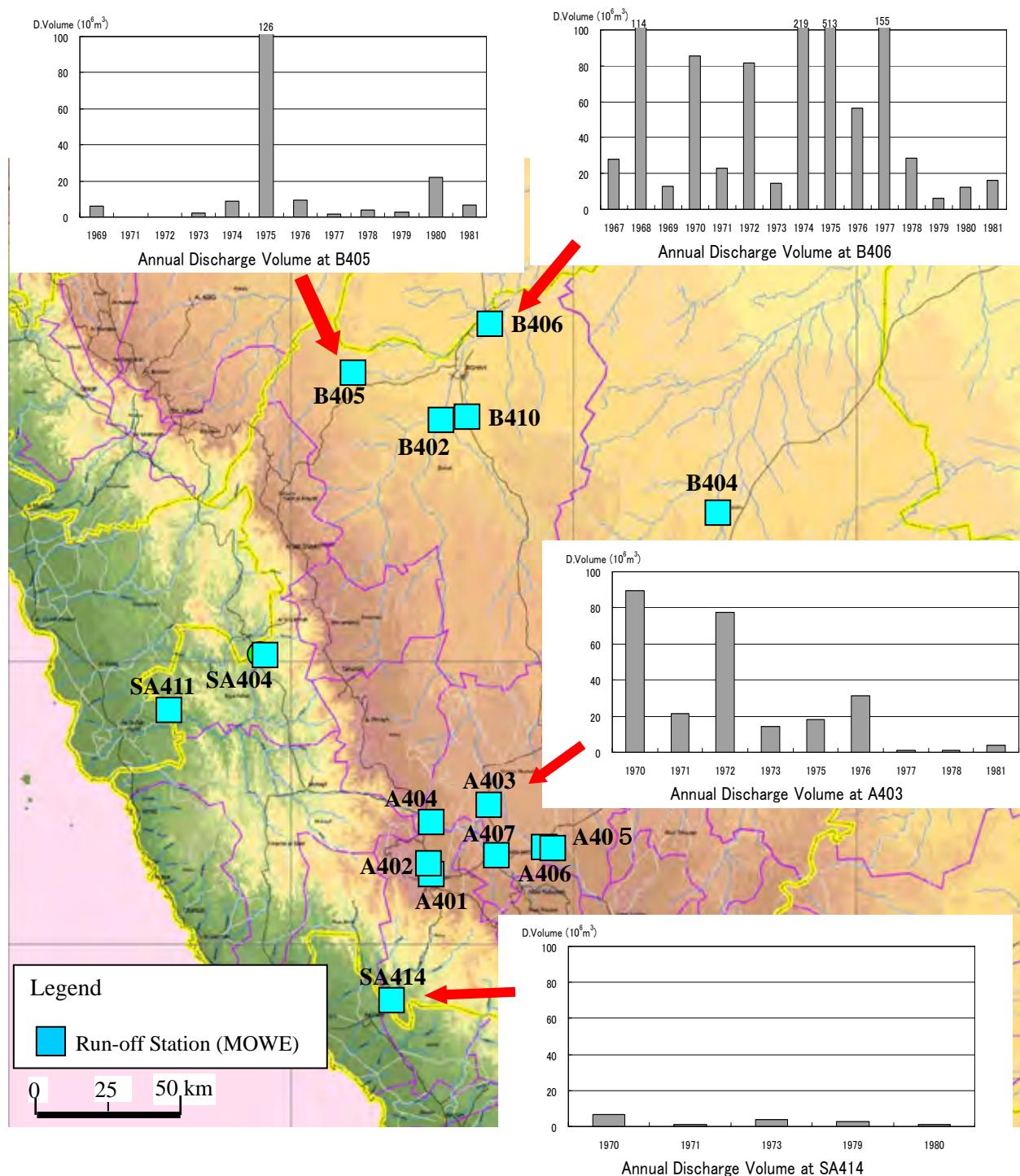
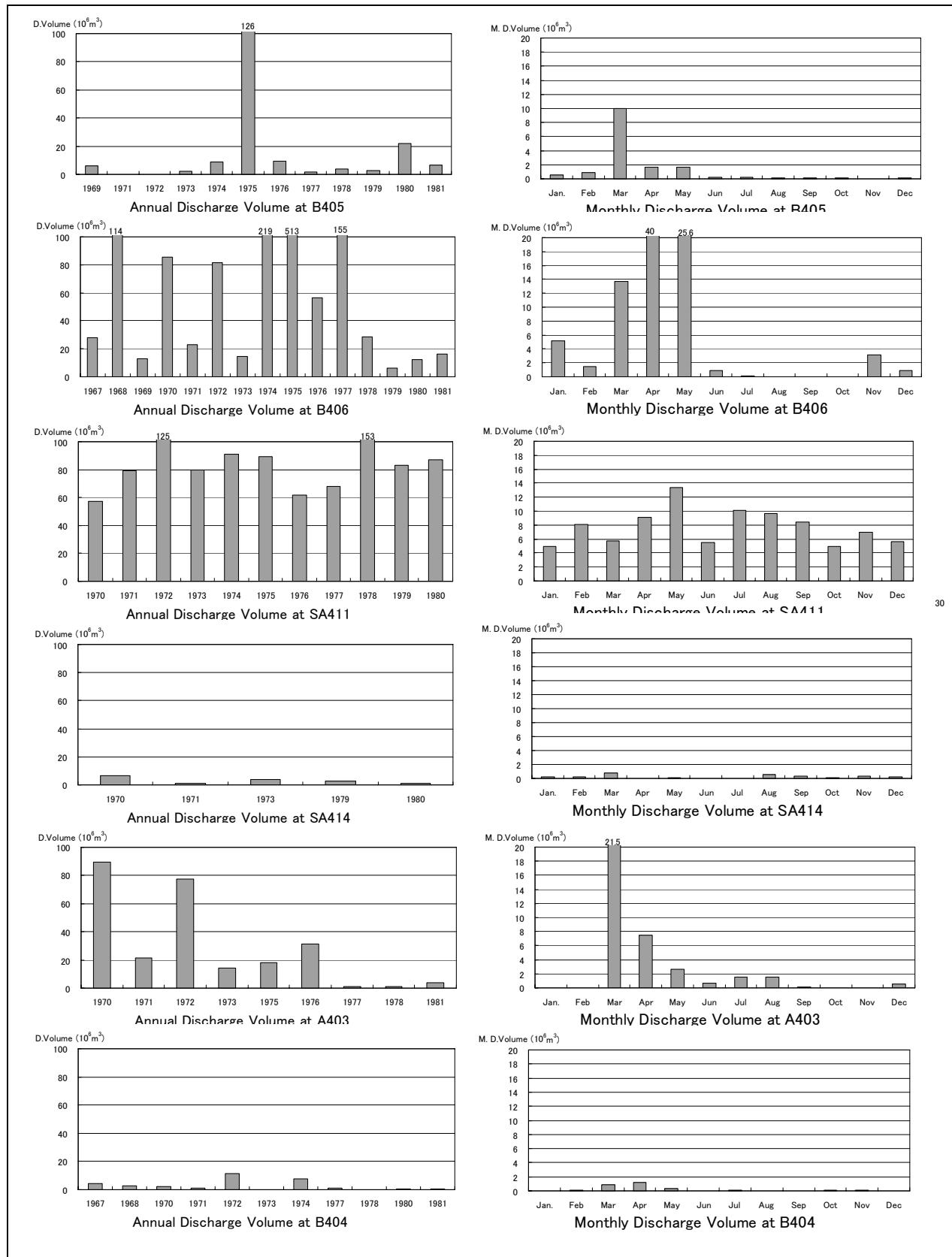


Figure3-7 Runoff Stations in Asir Region



Sources: MOWE

Figure 3-8 Change Over Years and Monthly Flow Distribution of Typical Runoff Stations

(4) Jazan Region

Tendencies for flow distribution are arranged and shown in Figure3-9 based on the flow data of the runoff stations shown in Figure3-10. And the specific flow and others are shown in Table3-5.

The flow characteristics in Jazan Region are summarized below.

- Mean Specific Flow ranges between $13,129 \text{ m}^3/\text{km}^2/\text{year}$ (13.1 mm/year) and $48,730 \text{ m}^3/\text{km}^2/\text{year}$ (48.7 mm/year), and there are a lot of flow matching the rainfall situation.
- Flow Ratio shows high number as over 10 percent in case of the exclusion of the northern part.
- There seems to be a lot of flow through March into May and through July into September.
- Specific Maximum Peak Discharge ranges between $0.20 \text{ m}^3/\text{s}/\text{km}^2$ and $0.40 \text{ m}^3/\text{s}/\text{km}^2$ except the northern part.
- There are comparatively a lot of flow in the center and southward specially, though there seems to be abundant flow in all.
- The water resources development might be effective in the center and southward area.

Table3-5 Flow and Others in Jazan Region

Runoff Station	C.A. (km^2)	Eleva-tion (El.m)	Mean Flow (m^3/year)	Mean Specific Flow ($\text{m}^3/\text{km}^2/\text{year}$)	Same as the left (mm)	Selected Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m^3/s)	Date of Occurrence	Specific Max. Peak Discharge ($\text{m}^3/\text{s}/\text{km}^2$)
SA415	4,713	200	61,878,197	13,129.3	13.1	SA145	402.6	1968–1969 1972–1976 1980–1981	0.033	170	Apr. 12 1971	0.04
SA417	1,000	130	39,051,619	39,051.6	39.1	SA140	408.6	1970–1981	0.096	251	Aug. 12 1975	0.25
SA418	1,200	*	58,475,919	48,729.9	48.7	SA104	391.6	1967–1981	0.124	480	Mar. 14 1981	0.40
SA421	900	99	40,337,654	44,819.6	44.8	SA135	264.7	1969–1974	0.169	176	Mar. 14 1981	0.20

Sources: MOW.E

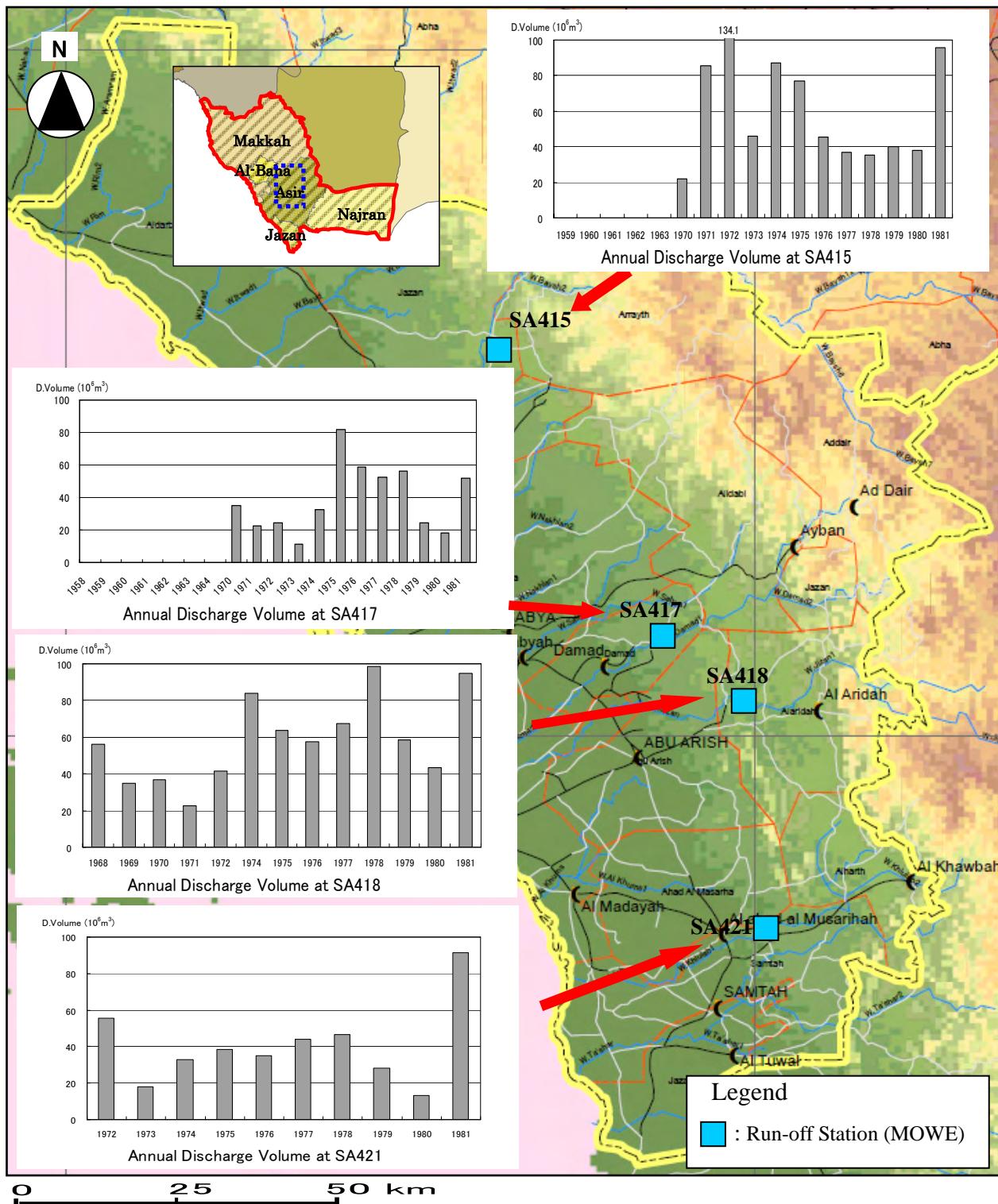
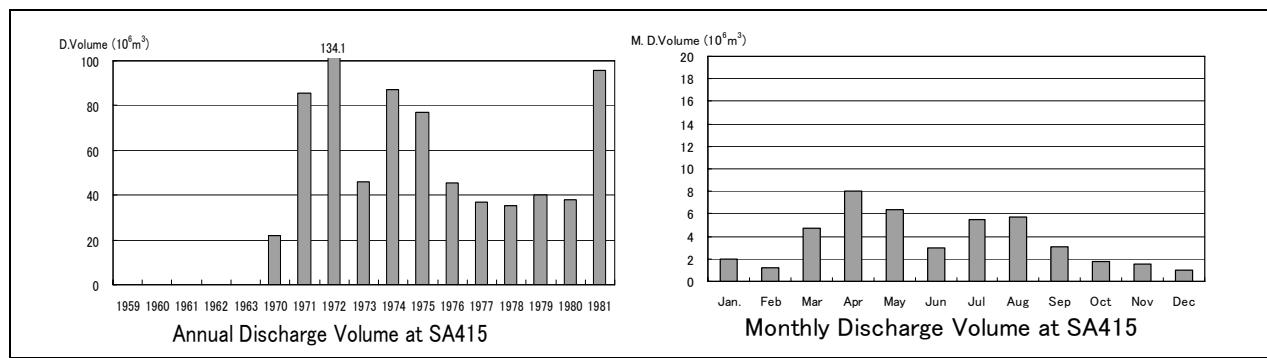
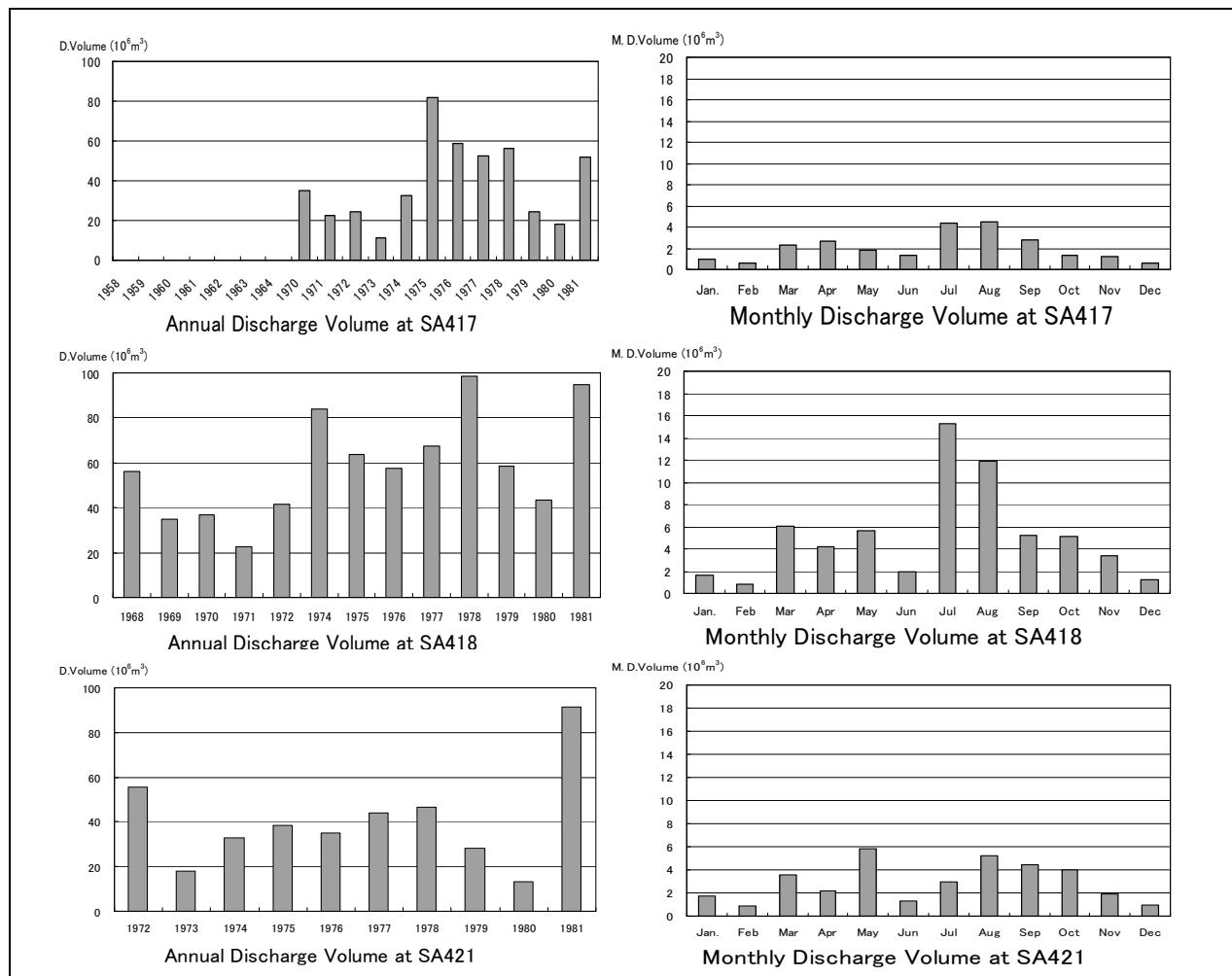


Figure3-9 Runoff Stations in Jazan Region



Sources: MOW.E

Figure 3-10(1) Change Over Years and Monthly Flow Distribution in Northern Part



Sources: MOW.E

Figure 3-10(2) Change Over Years and Monthly Flow Distribution in Center and southward

(5) Najran Region

Tendencies for flow distribution are arranged and shown in Figure3-11 based on the flow data of the runoff stations shown in Figure3-12. And the specific flow and others are shown in Table3-6.

The flow characteristics in Najran Region are summarized below.

- Mean Specific Flow shows high number as $17,904 \text{ m}^3/\text{km}^2/\text{year}$ (17.9 mm/year).
- Flow Ratio shows high number as 9 percent since most of that flow seems to flow down from Hijaz Asir Highland and the surrounding area.
- There seems to be a lot of flow through March into May and through July into August.
- Specific Maximum Peak Discharge shows high value as $0.15 \text{ m}^3/\text{s}/\text{km}^2$.
- It is thought that most of the flow from Hijaz Asir Highland and the surrounding area fade away for evapotranspiration before reaching the downstream because that the eastern part is occupied by the desert with 50 mm below in mean annual rainfall.
- Therefore the water resources development is limited in this small area near the border with Asir Region.

Table3-6 Flow and Others in Najran Region

Runoff Station	C.A. (km ²)	Eleva-tion (El.m)	Mean Flow (m ³ /year)	Mean Specific Flow (m ³ /km ² /year)	Same as the left (mm)	Selected Rainfall Station	Mean Annual Rainfall (mm)	Period	Mean Flow Ratio	Max. Peak Discharge (m ³ /s)	Date of Occurrence	Specific Max. Peak Discharge (m ³ /s/km ²)
N401	5,600	1,270	100,266,682	17,904.8	17.9	N103	202.7	1967–1976	0.088	813	Apr. 8 1969	0.15

Sources: MOW.E

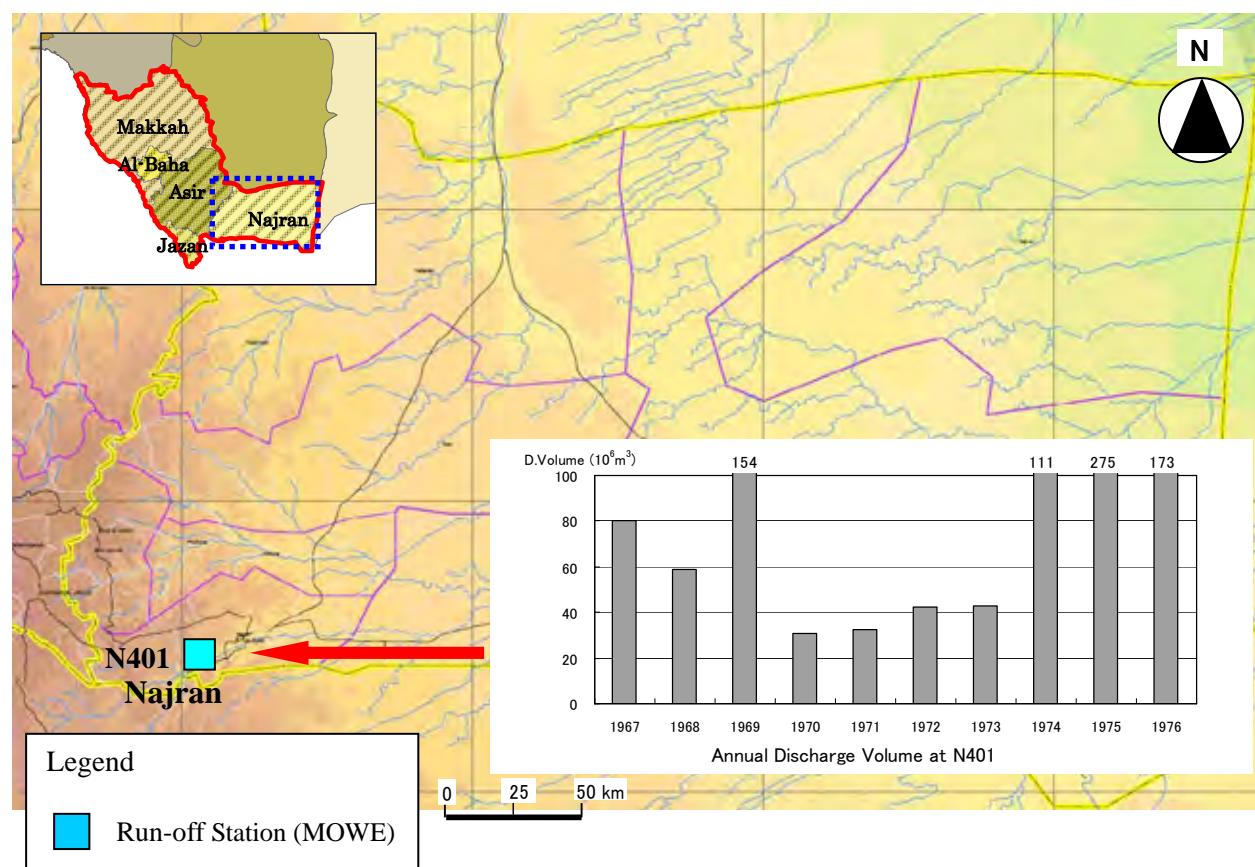


Figure3-11 Runoff Stations in Najran Region