$I(U_1, W_1; Y_1) \geq \frac{1}{n} I(M_0 M_1; Y_{1,1}^n)$, $I(U_2, W_2; Y_2|Y_1) \geq \frac{1}{n} I(M_0 M_1; Y_{2,1}^n | Y_{1,1}^n)$ and (M_0, M_1) can be recovered from $(Y_{1,1}^n, Y_{2,1}^n)$ with high probability. The fourth inequality holds because:

$$
\begin{aligned}
&n(R_0 + R_1) - nf_3(\epsilon) \\
&\leq I(M_0; Z_{1,1}^n, Z_{2,1}^n) + I(M_1; Y_{1,1}^n, Y_{2,1}^n | M_0) \\
&\leq I(M_0; Z_{1,1}^n, Z_{2,1}^n) + I(M_1, Z_{2,1}^n; Y_{1,1}^n | M_0) + I(M_1; Y_{2,1}^n | M_0, Y_{1,1}^n) \\
&= I(M_0; Z_{1,1}^n | Z_{2,1}^n) + I(M_0; Z_{2,1}^n) + I(Y_{1,1}^n; Z_{2,1}^n | M_0) + I(M_1; Y_{1,1}^n | M_0, Z_{2,1}^n) + I(M_1; Y_{2,1}^n | M_0, Y_{1,1}^n) \\
&= I(M_0, Z_{2,1}^n; Z_{1,1}^n) + I(M_0, Y_{1,1}^n; Z_{2,1}^n) + I(M_1; Y_{1,1}^n | M_0, Z_{2,1}^n) + I(M_1; Y_{2,1}^n | M_0, Y_{1,1}^n) - I(Z_{1,1}^n; Z_{2,1}^n) \\
&= \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n; Z_{1i} | Z_{1,i+1}^n) + I(M_0, Y_{1,1}^n; Z_{2i} | Z_{2,i+1}^n) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) \big) \\
&\quad - I(Z_{1,1}^n; Z_{2,1}^n) \\
&= \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n, Z_{1,i+1}^n; Z_{1i}) + I(M_0, Y_{1,1}^n, Z_{2,i+1}^n; Z_{2i}) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) \big) \\
&\quad - I(Z_{1,1}^n; Z_{2,1}^n) - \sum_{i=1}^n \big(I(Z_{1,i+1}^n; Z_{1i}) + I(Z_{2,i+1}^n; Z_{2i}) \big) \\
&\leq \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n, Z_{1,i+1}^n; Z_{1i}) + I(M_0, Y_{1,1}^n, Z_{2,i+1}^n; Z_{2i}) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) \big) \\
&\quad - \sum_{i=1}^n I(Z_{1i}; Z_{2i}) \\
&= \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n, Y_{1,1}^{i-1}, Z_{1,i+1}^n; Z_{1i}) + I(M_0, Y_{1,1}^n, Y_{2,1}^{i-1}, Z_{2,i+1}^n; Z_{2i}) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) \\
&\quad - I(Y_{1,1}^{i-1}; Z_{1i} | M_0, Z_{2,1}^n, Z_{1,i+1}^n) + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) - I(Y_{2,1}^{i-1}; Z_{2i} | M_0, Y_{1,1}^n, Z_{2,i+1}^n) - I(Z_{1i}; Z_{2i}) \big) \\
&= \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n, Y_{1,1}^{i-1}, Z_{1,i+1}^n; Z_{1i}) + I(M_0, Y_{1,1}^n, Y_{2,1}^{i-1}, Z_{2,i+1}^n; Z_{2i}) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) \\
&\quad - I(Z_{1,i+1}^n; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}) + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) - I(Z_{2,i+1}^n; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}) - I(Z_{1i}; Z_{2i}) \big) \\
&\leq \sum_{i=1}^n \big(I(M_0, Z_{2,1}^n, Y_{1,1}^{i-1}, Z_{1,i+1}^n; Z_{1i}) + I(M_0, Y_{1,1}^n, Y_{2,1}^{i-1}, Z_{2,i+1}^n; Z_{2i}) + I(M_1; Y_{1i} | M_0, Z_{2,1}^n, Y_{1,1}^{i-1}, Z_{1,i+1}^n) \\
&\quad + I(M_1; Y_{2i} | M_0, Y_{1,1}^n, Y_{2,1}^{i-1}, Z_{2,i+1}^n) - I(Z_{1i}; Z_{2i}) \big) \\
&= n(I(W_1, Z_2; Z_1) + I(W_2, Y_1; Z_2) + I(U_1; Y_1 | W_1, Z_2) + I(U_2; Y_2 | W_2, Y_1) - I(Z_2; Z_1)) \\
&= n(I(W_1; Z_1 | Z_2) + I(W_2, Y_1; Z_2) + I(U_1; Y_1 | W_1, Z_2) + I(U_2; Y_2 | W_2, Y_1)).
\end{aligned}
$$

The fifth inequality follows in a similar fashion, and the sixth one is similar to the third one. Hence the outer bound is valid.